SURGICAL OPERATIONS

Surgical Operations of the Head

ILLUSTRATED BY CLINICAL OBSERVATIONS, FOR

PHYSICIANS AND SURGEONS

BY

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504 Dural plastic, for covering the cystic lateral ventricle.

PLATE 86.—SUBDURAL FORMATION OF BONE IN THE CENTRAL REGION *Page* 518

505 Exposure of the central region.
506 Excision of the bony plaque.
507 Bony plaque, inner aspect.
508 Removal of the altered arachnoid.

PLATE 87.—CYST FOLLOWING AN OLD MASTOID OPERATION, I. *Page* 520

509 Incision for removal of scar.
510 The cyst exposed.
511 The cyst opened.
512 Making the osteoplastic flap.

PLATE 88.—KÖNIG-MÜLLER PLASTIC FOR COVERING THE CYST CAVITY, II. *Page* 521

514 The osteoplastic flap is turned down.
515 The first flap is sewn in, and a second is formed, consisting of skin only.
516 Implantation of the second skin flap.
517 The remaining defect is lessened by tension sutures.

PLATE 89.—EXTIRPATION OF A TUMOR OF THE FRONTAL REGION, PLATE A. . . . . *Page* 538

521 Double trapdoor necessitated by the large area to be exposed (first stage of operation).
522 Formation of two dural flaps (downward and backward).

PLATE 90.—EXTIRPATION OF A TUMOR OF THE FRONTAL REGION BY SUCTION, PLATE B. . . . . *Page* 539

523 Suction is applied to the tumor.
524 Division of the medulla forming the pedicle of the tumor.
525 The two dural flaps are turned in on the bed of the tumor.
526 Condition three weeks after extirpation of the brain tumor.

PLATE 91.—ENUCLEATION OF A TUMOR OF THE CENTRAL REGION

FIG. *Page* 545

527 Exposure of the dura mater (first stage).
528 The dura mater is opened in the form of a flap.
529 The tumor is lifted out by traction on the dura mater.
530 The dural flap with the adherent tumor is cut away.
531 Bed of tumor exposed.

PLATE 92.—EXTIRPATION OF A RECURRENT TUMOR OF THE LEFT TEMPORAL LOBE . . . . . *Page* 555

535 Prominence of the temporal region, from recurrence of previously operated tumor.
536 The tumor is enucleated with the index finger.
537 The osteoplastic opening is enlarged in front, above and below.
538 Cystic swelling in the depths of the tumor bed (lateral ventricle).
539 Suture of the opened ventricle.

PLATE 93.—EXTIRPATION OF A HYPOPHYSEAL TUMOR THROUGH THE ANTERIOR FOSSA, BY THE METHOD OF F. KRAUSE . . *Page* 580

554 Exposure of the right temporo-parietal region.
555 Exposure of the anterior and middle fossæ, right.
556 The tumor is freed up with the forefinger.
557 Beyond the middle line tumor masses remain in places.

PLATE 94.—DRAINAGE OF A POSTOPERATIVE HYDROCEPHALUS EXTERNUS BY MEANS OF VEIN-IMPLANTATION AFTER THE METHOD OF PAYR *Page* 585

559 Incision.
560 Dissection of veins.
561 Opening of the hydrocephalic sac.
562 Crescentic excision of the sac wall.
563 Oblique division of the vein to be implanted.
564-565 Fixation of the lumen of the vein by two holding sutures.
566 Medial suture completed; lateral row of stitches in place.
567 Implantation of vein completed; a small opening in the sac wall which remains is sewed up.
568 Condition after completion of skin suture.

PLATE 95.—EXPOSURE OF BOTH POSTERIOR FOSSÆ . . *Page* 595

571 Dissection of the left occipital vessels.
572 Occipital vessels on the left are double tied and divided.
573 Exposure of the right occipital vessels.
574 Three drill holes made; on the left the dura is being separated, on the right bony incision completed.
575 Prying up the bone plate.
576 Cerebellar fossæ of occipital bone turned down.

PLATE 96.—INTRADURAL DIVISION OF THE AUDITORY NERVE, AFTER F. KRAUSE . . . . . *Page* 610

FIG.
584 Exposure of the right posterior fossa.
585 Cutting the dural flap.
586 Exposure of the internal auditory meatus.
587 Separation of the auditory from the facial.
588 Operation completed.

PLATE 97.—ENUCLEATION OF A TUMOR OF THE CEREBELLO-PONTINE ANGLE . . . . . *Page* 617

592 Exposure of the left cerebellar hemisphere.
593 Exposure of the tumor.
594 Enucleation of the tumor with a large dull curette.

PLATE 98.—SUCTION APPLIED TO A TUMOR OF THE CEREBELLO-PONTINE ANGLE . . . . . *Page* 620

595 Exposure of the tumor.
596 Suction applied.
597 Freeing the tumor by means of a blunt curette.

PLATE 99.—EXTIRPATION OF TWO SOLITARY TUBERCLES, ONE FROM EACH HEMISPHERE . . . . . *Page* 628

599 The dura over both hemispheres is exposed.
600 A flap is made of the dura on the left side.
601 Shelling out the tubercle on the left side.
602 A flap is made of the dura on the right side.
603 Shelling out the tubercle on the right.

PLATE 100.—EXTIRPATION OF A TUMOR IN THE REGION OF THE VERMIS *Page* 631

605 Exposure of the region of the vermis.
606 The tumor is isolated.
607 The wide exposure of the fourth ventricle, following the extirpation.

PLATE 101.—EXPOSURE OF THE FOURTH VENTRICLE . . *Page* 635

608 The soft parts have been dissected away, and the middle portion of the posterior fossa removed.
609 Incision in dura mater.
610 Exposure of the vermis and medulla.
611 The fourth ventricle.

PLATE 102.—PERMANENT DRAINAGE OF HYDROCEPHALUS BY IMPLANTATION OF A CANNULA . . . . . *Page* 656

618 General view; drill hole after clearing off periosteum.
619 The cannula is introduced into the lateral ventricle.
620 A steel staff has been passed into the silver cannula, and on this the cannula is cut off.
621 The cannula is made fast under the periosteum.

PLATE 103.—PUNCTURE OF THE CORPUS CALLOSUM, AFTER ANTON AND V. BRAMANN . . . . . *Page* 660

FIG.

622 Exposure and incision of the dura.
623 The cannula is introduced subdurally as far as the falx.
624 The cannula is pushed through the corpus callosum.

PLATE 104.—OPENING AN ABSCESS IN THE TEMPORAL LOBE *Page* 665

627 Exposure of the temporal lobe.
628 Incision is made along the exploring needle.
629 The finger is introduced into the abscess cavity.
630 Drainage of the cavity.

PLATE 105. SUPPURATING TUBERCULOSIS OF THE CRANIUM . *Page* 678

631 Exposure of the abscess and the surrounding normal bone.
632 The tuberculous portion of bone is removed.
633 Section of the bone after removal.

PLATE 106.—REMOVAL OF A BONY SPLINTER FROM THE CENTRAL REGION *Page* 684

634 Incision for osteoplastic opening.
635 Exposure of the injured central region.
636 Extraction of the fourth splinter, situated within the brain.

PLATE 107.—REMOVAL OF A KNIFE BLADE FROM THE RIGHT TEMPORAL LOBE, AFTER FIFTEEN YEARS . . . . . *Page* 686

637 Knife blade within the cranial cavity, as shown by the X-Ray plate.
638 Cutting out the osteoplastic flap.
639 The knife blade is just visible in the anterior inferior angle of the wound.
640 Blade in process of removal, together with its attached capsule.

PLATE 108.—EXTIRPATION OF A SARCOMA OF THE DURA . *Page* 689

641 Incision.
642 Exposure of the tumor.
643 In removing the tumor a strip of the wall of the longitudinal sinus is cut away.
644 Incisions for plastic flaps to cover defect.

PLATE 109.—RESTORATION OF THE DURA MATER BY FASCIA LATA, AFTER KIRSCHNER . . . . . *Page* 697

646 Exposure of the dura mater and of the injured area in the frontal brain.
647 Exposure of the brain over the operative field.
648 Excision of the flap in the fascia lata.
649 Free transplantation of fascia.

PLATE 110.—EXTIRPATION OF AN INFERIOR OCCIPITAL ENCEPHALOCELE

FIG. *Page* 702

650 Excision of the sac.
651 Defect in the occipital fossa exposed.
652 The defect in the skull is covered by a flap of periosteum and galea.
653 The flap is sewed over the opening.
654 The tissues are sewed up in layers.
655 Condition six weeks after operation.

PLATE 111.—EXTIRPATION OF A PERICRANIAL SINUS . . *Page* 707

658 The sinus is exposed, and a circular incision is made about it.
659 The sac of the sinus, together with the periosteum, is freed up with a dissector.
660 The bone is bared by the removal of the periosteum.
661 Bony defect; formation of osteoplastic flap.
662 Osteoplastic closure completed.
663 Condition after sewing in the two flaps.

PLATE 112.—RE-IMPLANTATION OF SKIN FLAPS, FOR COSMETIC REASONS *Page* 709

664 Condition eight weeks after the osteoplastic operation.
665 Freeing up the flap in subcutaneous tissue.
666 The two skin flaps, after being dissected up, are restored to their original sites.
667 Result.

CHAPTER 13—SURGICAL PROCEDURES ON THE UPPER AND LOWER JAW

INJURIES OF THE JAW

Injuries of the jaw-bone arise practically without exception as the result of direct trauma. If a fracture occurs, it is usually compound, because of the thin covering of mucous membrane within the mouth, and it then demands special surgical treatment.

Diagnosis usually offers no difficulties, for even with extensive swelling of the soft parts, the fracture may be recognized by the chief symptom, abnormal mobility of the fragments. In order to demonstrate this, in fractures of the upper jaw one must place a finger or spatula within the cheek pouch, and in fractures of the lower jaw, one must seize the alveolar process on either side firmly with thumb and forefinger of both hands and ask the patient to make a chewing motion. Dislocation of the fragments is usually present, and when this is not recognizable by observation through disturbance of facial symmetry or distortion of the line of teeth, the "open bite" points definitely to fracture. Only in cases of double fracture of the upper jaw, through both canine fossæ, is displacement unlikely, and the fracture is then recognized by pain on palpation of the two pterygoid processes, which are always involved. Moreover, as in every fracture, pain on manipulating the fragments is of diagnostic significance.

Later, extensive hemorrhage into the soft parts of the face, an uncommonly marked edema, or other results of the external violence under which the fracture took place may render the diagnosis more difficult. On account of the thin covering layer of soft parts, particularly over the lower jaw, fractures are usually accompanied by wounds of the oral mucous membrane or of the skin of the face. Therefore there frequently occurs considerable hemorrhage into the oral cavity, and in case of fracture of the upper jaw into the nose. If the wall of the antrum of Highmore is cracked or broken through there is likely to occur, in addition, an extensive emphysema of the face.

In spite of the fact that practically all fractures of the jaw are

compound, the danger of infection is not excessive, because mucous membrane wounds in the mouth heal very readily. Even when loose spicules of bone disorganize and fail to heal in, as the result of being exposed in the oral cavity by mucous membrane injuries, further spread of infection is nevertheless of very unusual occurrence. We have already shown on page 141 how such fragments of bone may lie for a long time without causing anything beyond local symptoms. After weeks or months they are likely to become necrotic and find their way out.

Wounds of the mucous membrane usually require no treatment, but if they bleed badly they should be packed with gauze. Iodoform, of course, is better suited than sterile or other impregnated gauze for this purpose, because it prevents putrefaction of the wound secretions. Primary suture of mucous membrane wounds is to be considered when the wound edges are widely separated or have retreated from the underlying strata. It may be indicated to shut off the site of fracture from the oral cavity and to protect it against the secretions, with the idea of preventing necrosis of the fragments. Nevertheless, one must recognize that in doing this one seals a wound which is frequently infected, and which under any circumstance is unclean.

Wounds of the soft parts of the face, resulting from external violence, do not occur so commonly as wounds of the mucous membrane. They are treated according to the principles already given; but so long as the skin remains intact over the torn soft parts or bony fragments, all surgical procedures from without are to be avoided.

A more significant complication of fractured jaw than open wounds of the soft parts is permanent displacement of the fragments. It is important to anticipate and prevent this, particularly in fractures of the lower jaw. In fractures of the upper jaw the fragments seldom undergo so marked a displacement that there results a permanent disturbance of function, or danger to life. It is usually sufficient in fractures of the upper jaw to replace the movable fragments with the finger or an instrument within the mouth, since, as a rule, such fragments heal in successfully between the soft parts. It is wrong to resect at once loose fragments which are held in connection with the major fragments by only a few strands of tissue, in the upper as well as the lower jaw, in order to promote healing. On the other hand, they should be replaced as quickly as possible, because even if they do not heal in themselves,

they at least hold the bones apart until a definite callus can be formed.

If in spite of reposition several good-sized fragments remain loose, as happens particularly in splinter fractures of the lower jaw, and not infrequently also when the entire alveolar process breaks away from the upper jaw, the fragments may be fixed in place by means of fine silver or aluminum-bronze wire encircling the teeth on either side of the fracture. At the present day, even in case of slight displacement of the teeth, it is wise to call in the assistance of an expert dentist. It is generally agreed that one should employ such professional support in these cases, since the dentist can prevent harmful displacement of the fragments and encourage successful functional results through the employment of a wire network around the teeth, after the method of Hammond or Sauer, or through the use of interdental splints, crowns or prothetic appliances.

Moreover, it is important to take the utmost care of the mouth during wound healing by means of mouth washes, such as hydrogen peroxide, in order to limit the stomatitis which so frequently follows injuries within the mouth, and the putrefaction which results.

In the lower jaw fracture of the chin, the body of the mandible, is associated with particular danger. If this section is separated from the ramus of the jaw, it is pulled down very easily by the powerful muscles of the floor of the mouth, and may, through a falling back on the hyoid bone and tongue, cause danger of suffocation. This sort of injury follows most frequently upon self-inflicted bullet wounds. The body of the jaw may be completely shattered and fragments of the bone and of the bullet may be scattered through the soft parts of the face. In these cases surgical assistance must be limited to allowing free exit for the wound secretions and to co-operation with the dentist in holding the fragments of the jaw in proper position. Above all things, one should avoid beginning with removal of splinters of bone, since a defect may result which is too great ever to be bridged over. Many of the spicules heal in, contrary to expectation, by new bone formation, or they are sooner or later thrown off through fistulæ, externally or into the mouth, after the union of the fragments has been assured through the formation of callus.

If the middle portion of the lower jaw is broken on both sides in front of the masseter, there arises danger that consolidation follow under the pull of the muscles of the floor of the mouth and the

hyoid. Then there results an "open bite," when the teeth of the lower jaw come in apposition with those of the upper jaw only behind the line of fracture—that is to say, in the molar region—while in front at the chin they are widely separated as the result of displacement.

INFLAMMATORY DISEASES OF THE JAW

Osteomyelitis is much less frequently observed in the jaw than in other bones. It develops in this region in children in connection with acute infectious diseases, but more frequently as part of a multiple osteomyelitis. The lower jaw is affected more frequently than the upper, with the exception of the malar process, which even in earliest childhood may be the seat of a primary focus limited to this region. A fistula below and external to the outer canthus points usually to this condition, and, in later years, a sunken scar with more or less ectropion of the lower lid.

The treatment of acute and chronic osteomyelitis of the jaw is not different from that of the same condition in other bones. A subperiosteal abscess should be incised early. But even a considerable swelling and extensive necrosis of the affected bone, particularly if it be the lower jaw, should not induce one to resect early. For the sequestrum should be maintained during the period of demarcation and until the newly created bony mass forms a sufficient support. The removal of the sequestrum can be more easily accomplished from without, in the lower jaw through an incision parallel to and below the margin of the jaw, where the scar will later cause the least disfigurement. And one should avoid extracting the teeth from a jaw which is affected with osteomyelitis even when they seem to be loose and movable, for with the new formation of bone, they may again become solidly fixed in place.

A dangerous complication arises when an osteomyelitic focus breaks through under the mucous membrane of the gum or the floor of the mouth. For in the loose connective tissue which unites the muscles which arise from the lower jaw, the purulent or serous infiltration proceeds into the pouch occupied by the submaxillary gland, which is shut off externally by strong fascia, and proceeds from this place into the soft parts of the neck, or even into the mediastinum. As the result of the swelling the tongue and soft palate are pushed back against the posterior wall of the pharynx. Swallowing and the taking of nourishment may be completely blocked, and saliva

flows out of the mouth. If the inflammatory edema and infiltration continues to make its way under the mucous membrane in the mouth without involving the interstices of the muscles, within a short space of time the entrance to the larynx is reached and respiration is endangered as a result of the edema of the glottis.

The clinical picture of a cellulitis proceeding along the floor of the mouth with involvement of the submaxillary pouch and the muscles of the neck is known by the name of Ludwig's Angina, and it is recognized on account of its extremely rapid progress as one of the most dangerous of infections. The treatment consists in exposing the osteomyelitic focus, opening wide the infected soft parts within the mouth, and deep incision of the boardlike infiltration between the lower jaw and the hyoid bone, so as to open the submaxillary pocket. When danger of suffocation arises, a tracheotomy must be performed at the same time the focus is opened. One does not always succeed, even by the most radical measures, in putting a stop to the rapid spread of the purulent inflammation and the general septicemia which results. Usually no fluid pus comes out through the incision in the infiltrated tissue, but instead only a little discolored, foul-smelling fluid; and the disease frequently ends fatally in spite of early and extensive incision of the floor of the mouth and of the muscles of the neck, with symptoms of the most severe general infection.

Similar fulminating infections are also observed as the result of osteomyelitis in the upper jaw or following an extensive sub-mucous infection from a wisdom tooth. First, there develops from the gum a retro-maxillary cellulitis, which rapidly extends to the pterygopalatine fossa, and from there to the orbit and meninges. Practically without exception, as the result of the local and general septic infection, it leads to a fatal termination (see p. 315).

PHOSPHORUS NECROSIS

A true primary inflammation of bone which is observed only in the jaw is the necrosis which results from the action of phosphorus. This disease formerly developed chiefly in persons working in match factories, as the result of inhalation of phosphorus vapor, but since the employment of yellow phosphorus has been prohibited by law in the manufacture of matches in practically all countries, the occurrence of this disease has become quite infrequent. Phosphorus is inhaled and makes its way through carious teeth into the substance

of the jaw-bone. At the beginning of the disease it excites an active formation of new bone on the part of cortex and periosteum, but later necrosis or purulent decomposition of the affected bone sets in.

At first swelling of the jaw is the only external sign of the disease, and it is later, after secondary infection of the necrosed bone sets in, that numerous fistulæ arise from which foul-smelling, putrid pus discharges, and in the depths of which the probe comes up against bare necrotic bone. The danger of the disease, apart from the phosphorus poisoning, lies in the septic intoxication which results from the many purulent foci, and this is increased by a peculiar infection of the stomach and intestine, which is the result of the direct and constant irritation of their mucous membranes through the purulent wound secretions which are swallowed with the food.

For this reason, and since without operative removal of the sequestra the disease advances in more than half the cases and ends fatally, the treatment must consist in early and radical resection of the affected portions of bone. A partial subperiosteal resection of the jaw practically always suffices, for in phosphorus disease, just as in osteomyelitis, we are dealing with an affection which is limited to the bony substance. But even if in chiseling away the foci and thoroughly curetting the sinuses the greater part of the jaw, and at times the entire jaw, has to be removed, nevertheless as a rule the periosteum and its bone-forming layer remain behind, and through their activity the continuity of the lower jaw may be assured. In addition, treatment consists of absolute avoidance of the poisonous phosphoric gases, attention to the cleanliness of the mouth, milk diet and the exhibition of iodine preparations.

ACTINOMYCOSIS

Actinomycosis of the jaw is usually combined with extensive inflammation of the soft parts and is more commonly observed in the lower than in the upper jaw. The disease shows itself at first by a tumorlike thickening of the jaw-bone or as a swelling of the periosteum, which is hard to palpation. Later, abscess develops and the pus breaks through into the mouth or externally. There result numerous sinuses in the face, in advanced cases in the neck, and sometimes down as far as the breast. The diagnosis depends upon the demonstration of the ray-fungus in the small yellow kernels which come out with the pus through the fistulæ, or lie scattered about in the inflamed indurated soft parts.

J. Israel refers actinomycotic disease of the jaw to the entrance of the fungus into defects of carious teeth. But the very frequent primary affection of the soft parts of the face, and particularly the parotid, with secondary inflammation of the jaw-bone, speaks against this assumption.

The prognosis of actinomycosis of the lower jaw is not unfavorable under energetic treatment. Localization of the disease in the upper jaw is more dangerous on account of the spread of the actinomycosis, and particularly on account of the extension of the secondary purulent infection of the soft parts to the meninges.

Surgical treatment consists in early incision of the inflamed area, partial resection of the affected section of the jaw, in the lower jaw so far as possible without destroying its continuity, with a thorough curetting of fistulæ and extraction of all carious teeth. In addition, potassium iodide is given internally and subcutaneously, as there is ascribed to it a specific action in this disease.

TUBERCULOSIS

Ordinarily the jaw is an uncommon locus of tuberculous disease. The lower jaw is only affected secondarily, from foci in the mucous membrane of the mouth or gum.

Localized tuberculosis is likely to occur in the upper jaw, particularly in children. By predilection the lower margin of the orbit and the malar process are affected. At first, so long as there is no softening of the affected sections, the diagnosis may be difficult. It may be confused particularly with sarcoma, if the only symptom present is a spindle-shaped swelling of the affected bone. The differential diagnosis is rendered more difficult by the diffuse swelling of the entire malar region which occurs in tuberculosis as well as in sarcoma. In tuberculosis of the zygoma, localized inflammatory changes are likewise not at first evident externally, as the tightly stretched temporal fascia resists for a long time the progress of the tuberculous disease toward the surface, and perforation.

The destruction involves also the neighboring portions of the upper jaw or orbit; it leads to inflammatory swelling of the parotid, edema of both eyelids, and pain on motion of the articulations of the jaw. In other parts of the upper and lower jaw the diagnosis of tuberculous disease seldom offers similar difficulties, particularly if at the same time foci are apparent elsewhere in the body, or enlarged glands or other signs suggest a tuberculous diathesis. The

true nature of the disease is still more evident if several tuberculous foci have softened down and fistulæ occur on the face lined with the characteristic glassy granulations.

In children, circumscribed foci of tuberculosis in the upper jaw usually heal without surgical interference, particularly under the influence of a strengthening diet and improved climatic or hygienic conditions. Nevertheless, incision of abscesses, curetting of granulations, removal of sequestra and partial resection cannot always be avoided. The destruction of the lower margin of the orbit usually leaves behind a characteristic scar which is adherent to the bone and which in time may lead to a marked ectropion of the lower lid. Disfiguring funnel-shaped sunken scars which lie externally to the outer canthus at the point of junction of zygoma and upper jaw can, according to Neuber, be freed up from the lower strata and corrected by the transplantation of free fat.

Tuberculous disease of the jaw has a less favorable prognosis in adults, since it is likely to be a manifestation of a general tuberculosis. Its course is seldom as favorable as in children. From the upper jaw the destruction, as a rule, proceeds rapidly to the orbit, penetrates the ethmoid into the nose, or follows the orbital fissures to the cranial cavity, and finally death results with manifestations of brain or meningeal tuberculosis. If possible, all the affected portions of bone as well as the indurated tissue and granulations should be resected with a wide margin. Ordinarily one can maintain enough of the jaw and of the skin so that the configuration of the face, in spite of wide resection of bone, need not be substantially destroyed. The following case demonstrates how a partial resection of the jaw for tuberculosis may be carried out.

In a twenty-six-year-old woman a spindle-shaped tumor developed over the right zygoma during the course of about three months. It extended upward under the temporal fascia, and below it passed over without any marked line of demarcation into the soft parts of the cheek. The patient never suffered spontaneous pain except in front of the ear on chewing. On palpation the zygoma could not be recognized. The tumor felt firm and fluctuation could not be clearly demonstrated. In addition, both lids of the right eye were edematous.

An incision above the zygoma, dividing the skin and the tight temporal fascia, brought to light a tumorlike mass of granulations and a small amount of fluid pus. The zygoma toward the upper

Partial resection of the upper jaw.

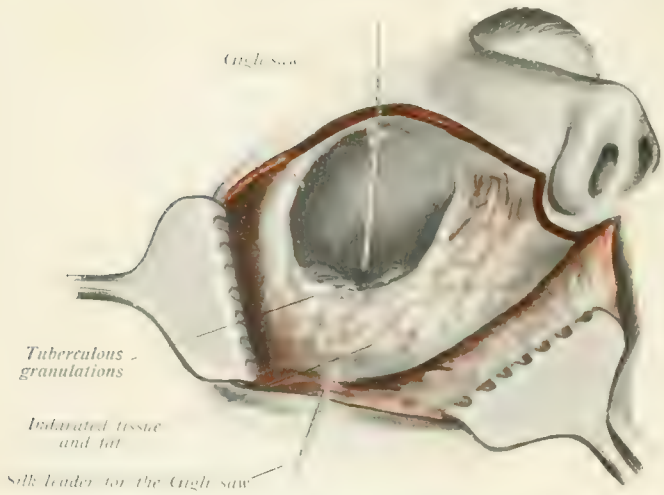


Fig. 295. The Gigli saw is drawn through the orbital fissure by a silk leader.

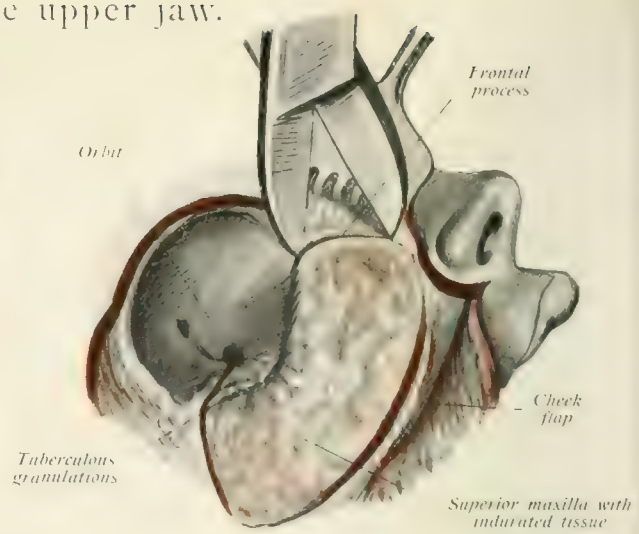


Fig. 296. The frontal process of the superior maxilla is divided with Liston forceps.

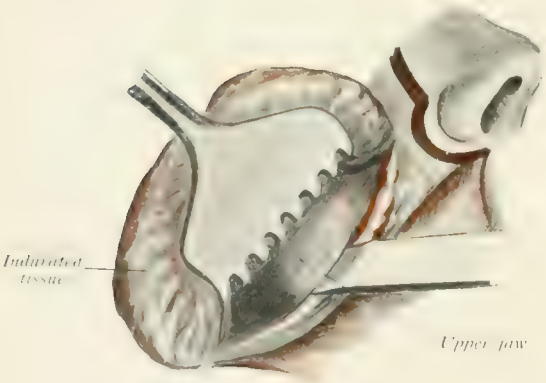


Fig. 297. Chiseling off the alveolar process.

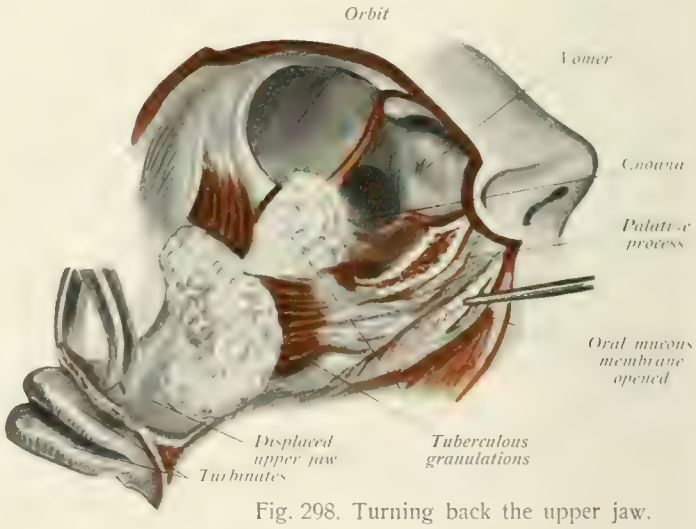


Fig. 298. Turning back the upper jaw.

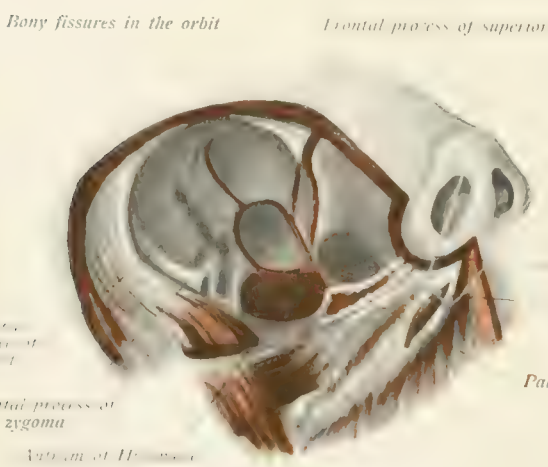


Fig. 299. Wound cavity after resection.

Fig. 300. Condition two months after resection.

jaw was completely destroyed and, except for a small stump in front of the ear, had to be removed. The periosteum was preserved entire. The wound was packed with iodoform gauze and five days later united by secondary suture, the cavity being filled with ten per cent. iodoform glycerine.

After satisfactory healing, about a year and a half later there was a recurrence with symptoms pointing to the orbit. By a Krönlein osteoplastic resection of the outer wall of the orbit (see Plate 33, p. 160) and cleaning out of the tumorlike granulation mass from the depths of the orbit, temporary alleviation only could be obtained.

Six months later the orbit was exenterated and the upper jaw partially resected. For this purpose, following the exenteration, the incision through the outer canthus was prolonged externally and in addition the Dieffenbach-Weber incision employed. This, after removal of the ciliated margin of the lower lid, ran to the inner canthus, down the side of the nose, around the ala to the filtrum. Further course of events demonstrated that this incision, on account of the ready movability of the soft parts, was entirely satisfactory.

At the side of the nose the incision was carried down to the bone, which at this point was intact. The flap, comprising practically the entire right cheek, with the base lying external and below, was freed up starting from this point, and the outer portion of the bony orbit satisfactorily exposed. The malar process and the lower margin of the orbit were entirely replaced by tuberculous granulations. In order to remove all the diseased tissue, a heavy curved needle was passed through the infected tissue downward and outward under the malar bone and a Gigli saw was pulled through by means of a silk thread (Fig. 295, Plate 56). In this way the zygoma was sawn through from within outward. The junction of the upper jaw with the nasal bone was divided with the aid of strong bone-cutting forceps (Fig. 296, Plate 56). For this purpose the soft parts had to be pulled sharply to the middle line with a rake retractor. One blade of the bone forceps was slid through the pyriform aperture into the nasal cavity. The other was passed from the orbit in the direction of the inferior orbital fossa, and in this way the nasal process of the upper jaw was divided. After the soft parts of the flap had been freed down to the canine fossa and the mucous membrane fold of the mouth had also been dissected away from the bone,

the upper jaw could be chiseled through transversely just above the alveolar process (Fig. 297, Plate 56).

The now completely mobilized upper jaw was seized with bone forceps and broken away outward (Fig. 298, Plate 56). The nasal cavity was thus opened wide and the wound surface exposed, so that all bleeding could be readily controlled and no blood allowed to flow into the mouth. The upper jaw hung only by the pterygoid process, and temporarily was left in this position. In order to still further prevent flowing of blood into the nose and mouth, the entire wound was opened wide with rake retractors and the nasal cavity packed with vioform gauze. A prophylactic tracheotomy as well as a preliminary ligation of the carotid artery were considered. In the spheno-maxillary fossa tumorlike granulations were still to be seen. In removing these with a curette down to normal tissue, the internal maxillary artery was injured, but it was seized at once with two hemostats, divided and ligated. Finally, the upper jaw, which had been dislocated outward, had only to be separated from its attachments, and the pterygoid process divided with scissors.

The wound cavity, completely cleaned of sequestra and granulations (Fig. 299, Plate 56), had the following boundaries: above and to the outer side the wall of the orbit, in which no destruction from tuberculosis could be recognized; to the inner side the nasal septum, the lachrymal bone as well as the ethmoid and the turbinates having been removed on account of their being involved in the disease. In the depths of the cavity a considerable piece of the base of the skull had been removed with rongeurs and curette, as well as the right wall of the sphenoidal sinus, which now lay wide open and completely cleaned out. Since the tuberculosis did not extend to the frontal sinus, this did not have to be opened up, but on the other hand the various recesses, such as the inferior orbital fissure and the optic foramen, were thoroughly cleaned out so as to leave no infected tissue behind.

The mucous membrane of the mouth was injured in one place in the region of the incisor teeth, so that it had to be sewed up with five interrupted stitches of catgut. These did not penetrate the mucous membrane (Fig. 299, Plate 56). Finally, the wound was packed thoroughly with iodoform gauze, using particular care at the base of the skull, and the end brought out through the right nasal orifice. The entire wound of the soft parts was closed by careful approximation.

On the fifth day after operation and every second day thereafter a short piece of the packing was pulled out through the nose and cut off, until about the beginning of the third week the packing was entirely removed. All sutures had held and the scar formation was so favorable that the disfigurement of the patient was relatively slight (Fig. 300, Plate 56). A year and a half later she died of miliary tuberculosis, without having shown any local recurrence.

If the disease involves the hard palate, this must also be removed. In such case the incision is continued through the upper lip along the filtrum into the mouth, and the entire flap, including the half of the upper lip, is turned outward.

The division of the hard palate is accomplished in the middle line with a chisel after removal of one of the incisor teeth. The soft palate is divided transversely along the posterior edge of the hard palate.

If the disease has proceeded only as far as the upper surface of the palatal process, then the muco-periosteal covering of the hard palate can very well be preserved in connection with the soft palate. For this purpose the muco-periosteum of the hard palate is divided along the alveolar process and freed up with a raspatory medially as far as the middle line. Then the bony palate is chiseled through in the manner described. After the removal of the upper jaw the muco-periosteal layer is sutured laterally to the mucous membrane of the cheek, which renders the later employment of a prothetic appliance unnecessary.

BENIGN TUMORS OF THE JAW

Benign tumors of the jaw belong practically entirely to the connective tissue group. Among them tumors which arise from the bony substance or its coverings are to be definitely distinguished from those which stand in relation to the mature teeth or their primitive layers. To the first group belong fibroma, chondroma and osteoma, all of which show their benignity by the fact that they are hard to the touch, that they grow unusually slowly, that they never extend by infiltration into the surrounding tissues, and show no metastases or glandular enlargement. Many of them on growing into the neighboring tissue acquire a capsule out of which they can be shelled, together with their pedicle or base of origin.

The tumors which arise within the marrow space or inside the

cortex give evidence of this by the fact that in developing they cause a diffuse bulging of the jaw-bone. In this way they first acquire a bony shell, which in time becomes gradually thinner. On the other hand, tumors which grow from the surface of the bone or from the periosteum grow externally without in any way destroying the jaw. Once in a while they possess a real pedicle, which is disposed in the upper jaw to extend into the neighboring cavities, such as the antrum of Highmore.

Fibromata occur as central tumors in the lower jaw, and in their slow growth they can reach a considerable size. But in spite of their size and the disfigurement which results, they need cause no active symptoms. In the large tumors there frequently occur mixed forms, combinations of the purely fibrous, and the tissues which are generated from bony, cartilaginous, or mucous tissues. Transition forms of this benign tumor into sarcoma have also been described.

Chondromata sometimes develop in the body of the lower jaw, but more frequently in the alveolar margin of the upper. This hard nodular formation first arises in youth, and requires years and even decades to reach any considerable size. As tumors of the lower jaw they are clinically difficult to distinguish from fibromata, but they show a disposition to develop outward rather than centrally. Arising in the upper jaw, they are likely to puncture the thin wall of the antrum of Highmore, and later the orbit or wall of the nasal cavity, and they are particularly to be feared on account of the pressure which they cause upon the eye, and particularly injury to the optic nerve or eyeball.

Like fibroma and chondroma, *osteoma* may be observed about the jaw, either single or multiple. They occur infrequently in a diffuse form, which involves the entire lower jaw. The common form is that of exostoses, which arise from the cortical layer of bone. They exist as tumors with a broad base which, nevertheless, have a sort of pedicle. They develop on the upper jaw in the canine fossa, growing outward, or they grow inward on the wall of the antrum. They sometimes develop on the oral surface of the lower jaw, and cause difficulty in chewing and swallowing. The growth of exostoses along the alveolar margin is laid to the irritation of carious teeth or injury through their extraction, or to rachitis. Even tiny exostoses in this place may give rise to severe pain to the patient on chewing and talking.

On account of the functional disturbances which are associated

with the growth of benign tumors on the jaw, on account of the external disfigurement, secondary involvement of neighboring cavities, and finally the danger of malignant changes, removal of even benign tumors is indicated in every case. This, in extensive tumors, includes a partial resection of the jaw within the limits of unaffected bone, or if the neoplastic tissue and bone can be clearly differentiated from each other, the place of origin is chiseled away and the tumor, together with its capsule, cleaned out.

Osteomata which grow from the upper jaw into the antrum and orbit are particularly likely to possess such a capsule or shell, and may, as soon as their base in normal bone is resected, be readily separated out from the neighboring tissue, to which they are only lightly adherent. For exostoses on the alveolar margin wedge-shaped excision of the cortex with chisel and mallet is indicated. The mucous covering is first incised vertically, separated on both sides from the exostosis, and is finally sewed together over the point of resection.

Exceptionally, total resection of the jaw is necessary. In the lower jaw the surgeon should be particularly careful to break the continuity of the jaw only when that is absolutely necessary, and to maintain, when possible, the periosteum, or a bridge of periosteum and bone, from which the resected section may be regenerated.

ODONTIGEROUS TUMORS

From the clinical point of view the cysts and pure neoplasms which arise from the teeth or their primitive layers possess marked similarity to the connective tissue tumors of the jaw. Moreover, they are always to be considered as benign. They grow very slowly and never cause metastases. Externally they are not recognized without further investigation, for the only visible sign is a swelling on the jaw very similar to most of the other tumors of the jaw. But on account of their central position in the marrow space of the bone, they cause the cortex, as a rule, to bulge in its weakest place as the growth gradually increases. In the lower jaw they find the least resistance externally; in the upper jaw in the wall of the antrum of Highmore. Formerly these benign neoplasms arising from the teeth were observed in considerable size, but nowadays they come under observation earlier, and they are not seen to reach such large proportions.

Under cysts of the jaw there are to be differentiated *root cysts*

and the true *follicular tooth cysts.* The former develop in later years after dentition has been completed and take their origin in the tip of the root of carious teeth. According to Perthes, they represent a further developmental stage of inflammatory cystic root granulations which may be regarded as the result of a chronic peridentitis. Ordinarily they may be extracted as small seedlike attachments with the tooth, but in exceptional cases they grow inside the jaw to form cysts which develop until they cause bulging of the cortex of the bone and of the cheek, which is visible externally. In the upper jaw where the thin wall of the antrum of Highmore readily gives way under the slight but constant pressure, they are more apt to grow to a large size, so that they may completely fill the antrum and simulate the picture of hydrops of the antrum.

Follicular cysts, on the other hand, arise at the period of the second dentition, from a displaced tooth follicle which does not develop normally, but grows and finally breaks through externally. While the root cyst is more commonly observed in the upper jaw, the follicular cyst is equally common in the upper and lower jaw. Its wall is covered with epithelium arising from the enamel organ, and it contains, in addition to a clear yellow fluid rich in little plates of cholesterin, the rudiments of one or more teeth. The size may be readily observed, particularly in the lower jaw. Diagnosis of these two forms of cysts offers no difficulty on account of their spherical projection outward, particularly with the follicular cyst, if the X-ray gives any information concerning its contents. In advanced cases the thin shell of bone over the cyst may be dented in by external pressure, or on palpation it gives a parchment-like crepitus.

According to Partsch, the treatment of follicular cysts should be limited to the intra-oral removal of the anterior wall of the cyst, together with the muco-periosteal and bony covering, under local anesthesia. The cavity should be packed for several days with antiseptic gauze. Since the cavity remaining behind is lined with a layer of cells related to the epithelium of the gum, the inner lining of the cyst and the mucous membrane of the jaw heal together in short order. Later on, the cavity gradually fills in and forms a shallow depression which can be recognized with difficulty. Partsch has never observed any recurrence, in a large experience with this sort of tumor. In root cysts it is important to remove the responsible tooth, the tip of which at times projects into the cavity after the operation.

CYSTIC AND SOLID TUMORS

Cystic and solid tumors, which arise from mature teeth or their anlage, are much less frequently observed than true cysts. To this group of neoplasms in the jaw belongs a well-defined series of tumors which arise from the tissues of the teeth, comprising *cystoma, epithelioma* or *adamantoma,* and *odontoma.*

The first two are histologically closely related. They arise from the proliferated cells of the enamel organ and are both always of a benign nature, but they can be distinguished from each other in macroscopic and histological structure. The epithelioma are solid tumors, poor in blood vessels, which possess a capsule and can be clearly differentiated from the bone of the jaw. Cystoma, on the other hand, are inclined as they proliferate to infiltrate the bony substance. Nevertheless they show on cross section a sort of capsule, and are divided into segments of various size by septa of connective tissue.

The *odontoma* is distinguished from these two dental tumors of a soft consistency by its bony hardness. It arises from the mature cells of the dentine. As a rule it is located on the neck of a molar tooth, but it is ordinarily observed only in young people. On account of its connection with the mature tooth, it is commonly found at the edge of the alveolar process. It penetrates this by proliferation, with the formation of fistulæ, and in this way gives rise to confusion with osteomyelitic or tuberculous sequestra of the jaw. The true nature of the tumor is only recognized after operative exposure. In the same way, cystoma and epithelioma are frequently confused with sarcoma, and for this reason a considerable portion of the jaw may be resected. This is not necessary if these tumors are recognized in advance, which is not easy, except with the aid of the microscope after operation.

With the odontoma as well as the soft tumors, in order to effectively prevent recurrence, it is sufficient to expose the jaw-bone and to thoroughly remove the tumor from its surface with the gouge, or at least with the curette. In the lower jaw a resection which breaks the continuity should always be avoided, and in the removal of a benign tumor at least the periosteum and a bridge of bone should always be left behind.

MALIGNANT TUMORS OF THE JAW

The number of malignant tumors exceeds by a good deal that of the benign, in spite of the fact that these latter are observed in so many different forms. If one reckons *epulis*, the giant cell tumor of the alveolar process, with the sarcomata, the proportion of occurrence is still greater in favor of the malignant. Clinically, to be sure, this neoplasm occupies a middle place between the benign and the malignant, since it does not infiltrate the bone *en masse* as does a true sarcoma, but shows a tendency instead to grow outward from an alveolus on a pedicle or a small base. Also, after a resection carried out in normal tissue, there is no recurrence, nor are there glandular metastases.

This tumor can arise at any period of life, in the upper as well as lower jaw, but it practically always develops as the result of irritation upon the periosteum of a deep-lying, hidden, carious root. Sometimes the spongy vascular tumors show a disposition to more rapid growth so that they reach the size of a walnut, but usually they cause acute symptoms while they are still small, which bring the patient to the surgeon. Through their situation in the toothless alveolus, they hinder chewing. Their surface is injured at every attempt to close the teeth and active bleeding arises. Also, the neighboring teeth become loose. Ulcerations arise on the mucous membrane which covers them and gingivitis develops, causing an often astonishing degree of debility in relation to the limited size and the benignity of this tumor.

On account of the danger of recurrence in epulis, in order to remove the tumor with a wide margin of normal tissue, the mucous membrane of the jaw is incised down to bone a few millimeters distant from the base or pedicle of the tumor, scraped back with a narrow elevator, and the neoplasm with its base removed with the chisel by a wedge-shaped resection of the alveolar process. If, on account of the size of the tumor, the field is too limited, the neighboring teeth are extracted.

Hemorrhage from the bone may be considerable; nevertheless, for its control the introduction into the cavity of an iodoform gauze packing always suffices: it likewise serves as a protection to the wound surface. After two or three days the tampon is made smaller and the edge of mucous membrane which had been pushed back is replaced over the margin of the wound. The packing is renewed

until the wound is covered with granulations which lift out the gauze, and it then rapidly covers itself by the growth of mucous membrane from the edges. The defect, at first large, becomes rapidly smaller, and after healing causes practically no disturbance to the patient.

SARCOMA OF THE JAW

In contradistinction to the giant cell sarcoma, the course and prognosis of the centrally situated *myelogenous* and the *periosteal sarcoma* of the jaw are very unfavorable. In the first place, so long as these two forms of neoplasm give rise to no visible deformity and cause no symptoms, a radical removal is always possible in the upper as well as in the lower jaw. But it is very difficult to recognize the very slowly growing and almost symptomless myelogenous type. Later on, when recognition is less difficult, it is usually too late for a radical removal, particularly of the extremely malignant soft round cell sarcoma. Conditions are better with the less malignant hard periosteal spindle-cell sarcoma. This differentiation between these two forms of sarcoma hold particularly true in tumors of the lower jaw.

Diagnosis of sarcoma of the jaw rests upon a visible and palpable swelling of the jaw, upon the rapid growth of the tumor and the accompanying edema of the soft parts, and in many cases upon the enlargement of the veins of the skin in the neighboring regions of face and neck. In the upper jaw sarcoma grows by preference into the nose and its accessory sinuses, particularly into the antrum of Highmore, and as it increases in size pushes the eye and nose out of place. The periosteal sarcoma, in contradistinction to the benign tumors, develops ordinarily only on one side of the bone. At first it may be felt as a small, hard tumor which later grows rapidly, and which goes over into the periosteum and bone without any sharp outline. The myelogenous sarcoma on the lower jaw first pushes the cortical bone symmetrically before it, and remains covered with a layer of bone which, in the course of time, becomes increasingly thin, and usually shows on palpation the parchment crepitation. Only when in its continued growth it breaks through its external shell of bone can a hard edge of bone be felt in a ring around the soft tumor mass. Ordinarily sarcoma of the jaw, in comparison with carcinoma, causes only slight pain, and is not particularly disposed to cause glandular enlargement or to form metastases.

CARCINOMA OF THE JAW

True primary carcinoma never occurs either on the upper or the lower jaw, but the carcinomatous growths observed in these bones develop in them secondarily. They arise either from without from the epithelial mucous membrane covering the bone, or much less frequently centrally from the epithelial anlage of the tooth pulp. Carcinoma is much more frequent in the upper jaw than in the lower jaw, and develops by preference from the mucous membrane of the antrum of Highmore. The much less common carcinoma of the lower jaw, on the other hand, usually develops from the gum, and is identical with the carcinomatous metamorphosis of the mucous membrane of the mouth.

Carcinoma of the jaw is predominatingly a tumor of advanced age. Quite frequently there is observed an association with an antecedent syphilitic infection, and often the affection may be demonstrated as hereditary. Clinically, carcinoma of the jaw differs from the other tumors of the jaw in that its growth is accompanied in upper as well as lower jaw by a severe neuralgia, and that attacks of neuralgic pain may be the first evidence of the neoplasm.

As the carcinoma progresses in the upper jaw, there occur prominently symptoms referable to the antrum of Highmore, or to one of the other accessory sinuses, and as soon as the neoplasm has penetrated the outer wall of the sinus, signs of inflammation, particularly a rather firm and diffuse swelling of the affected cheek, appear. On account of the symptoms referable to the nose and its accessory sinuses, the papillary proliferation which breaks into the nasal cavity is commonly mistaken for mucous polyps, and treated as such. In many cases the diagnosis may be arrived at earlier, particularly if the carcinoma breaks through certain portions of the cheek or gum and the papillary granulations begin to degenerate.

In the lower jaw carcinoma practically always has its seat in the alveolar process. Here, at first, hard grayish-red masses arise on the mucous membrane, which later degenerate and form ulcers, and in the further course of the disease these extend over to the floor of the mouth and lower lip. While in the upper jaw the bony tissue is destroyed early, the lower jaw resists the advances of the neoplasm for a considerable time. The carcinomatous neoplasm extends first under and into the mucous membrane of the lip and gum, and later, as a rule, breaks through the lower lip or chin at the

lower margin of the jaw. Some time before this the submental and submaxillary lymph nodes become palpable as hard knots. If in the further course of the disease the skin infiltrated with cancer becomes necrotic, foul craterlike ulcers form on the chin, which extend down to bone and are adherent to it; their bases are covered with grayish-red papillary granulations. As a result of perforation into the oral cavity, saliva flows continually, and with every meal solid food and fluids appear in the wound. Then, as a rule, the muscles of the floor of the mouth and tongue become involved by the neoplasm, with the result that swallowing becomes difficult.

The bony tissue of the lower jaw, in spite of the extensive destruction of the soft parts, is affected only in its superficial layers. The further backward on the alveolar process the neoplasm arises, the earlier are the muscles of mastication and the articulation of the jaw involved. The extension of the cancerous infiltration is evidenced by the increasing degree of limitation of motion of the jaw. If the tumor grows along the floor of the mouth, the tongue will be affected early on its margin or its under surface, and together with the increasing swelling and loss of motility of the tongue, there develops a foul and extremely painful ulcerated surface. From the clinical point of view these different forms of carcinoma of the jaw can in no way be differentiated from those of the floor of the mouth, of the cheek, and tongue (see p. 369).

Carcinoma of the alveolar process arising from the mucous membrane is observed less often in the upper than in the lower jaw. Carcinoma of the jaw may develop from the mucous membrane of the lip and cheek or from the point of transition from the tongue to the floor of the mouth, as well as from the gum, and may secondarily affect the jaw. Also local recurrence of these or of carcinoma of the lip or salivary glands commonly take the form of tumors which grow fast to the jaw-bone and which must be treated as tumors of the jaw.

TREATMENT OF MALIGNANT TUMORS OF THE JAW

The treatment of sarcoma and carcinoma consists in radical removal of all the affected tissue. As compared with the benign tumors and epulis as well, partial resection of the jaw, such for instance as is described under tuberculous disease, suffices only in exceptional cases (see p. 276). The periosteum of the jaw should never be retained in resection for malignant disease, and particularly

in myelogenous sarcoma and carcinoma of the antrum, in which the danger of recurrence seems to be greater than with other tumors. In periosteal sarcoma and in carcinoma of the alveolar process on the lower jaw, a portion of the periosteum of the other side of the jaw may occasionally be preserved, if the tumor has not advanced too far. Less frequently a narrow bridge of bone may be left to maintain the continuity of the jaw. This is of great significance from the cosmetic point of view as well as regards speech, swallowing and mastication, since no prothetic appliance can imitate the natural curve of the jaw anywhere near so satisfactorily. Moreover, its construction and use is always associated with some difficulty to the patient.

Not only periosteum and bone, but the affected soft parts of the face must be resected as extensively as necessary, and the defect must be remedied immediately or later, according to the principles of cheek and lip plastics. But a plastic restoration of the face can succeed only if the loss of tissue is not too extensive, and if at least a portion of the upper jaw remains as support for the plastic flap. But in this connection the boundaries within which it appears possible to radically remove tumors of the upper jaw, with the idea of a permanent cure, seem to be definitely set. In very extensive infiltration of the soft parts, particularly of the skin of the cheek, by the tumor mass, attempts at radical removal seem to be particularly inadequate, because tumors of the jaw which extend early into the soft parts of the face belong to the most malignant and the most readily recurrent type of neoplasm.

The case reports in the literature represent what has become currently accepted, that patients with massive carcinoma of the upper jaw practically never have survived a simultaneous resection of half of the jaw and of the cheek. The basis for this opinion lies less in the technical difficulties than in the rapidly increasing debility which arises as the result of the long-continued interference with the ingestion of food. As a rule, even before operation the patients are greatly weakened, and have largely lost their resistive power as the result of the putrid decomposition of the carcinoma, frequently recurring hemorrhage, and the absorption of toxins elaborated in the tumor.

The prognosis in sarcoma which has spread widely into the soft parts after resection or exarticulation of the lower jaw must be considered just as unfavorable as in extensive carcinoma of the

upper jaw. If a radical removal of the neoplasm is to be done, a portion of the cheek and of the floor of the mouth must be sacrificed in addition to the bone, and the oral cavity opened wide. If this opening is not closed at once, all the saliva and the larger part of the nourishment which is taken flows out of the mouth. Even if a provisional closure of the oral cavity succeeds, in most cases, as a result of resection of the jaw and floor of the mouth, the ability to swallow is lost and the secretions of the mouth stagnate in the wound, infect it, or, together with portions of food, are aspirated into the lungs. We lose such patients usually very quickly after operation with increasing debility, pneumonia, or as a result of wound complications.

The outlook is much better after resection, if the skin of the cheek may be maintained complete or has to be removed only in such limited extent as to allow immediate suture of the wound edges. The prognosis is still better in case one succeeds in closing off the mouth and wound cavity entirely from each other by loosening up a mucous membrane flap and sewing it to the cheek. In the upper jaw this may be accomplished if the walls of the antrum are not completely destroyed, and particularly if, in addition to the cheek, the hard palate, or at least its major portion, can be preserved. In the lower jaw, after resection, the oral cavity can be shut off more readily by suture of mucous membrane or by a plastic operation the farther back toward the angle of the jaw the tumor is situated, because here there is more mucous membrane, and it can be better employed for plastic purposes on account of its loose union upon the underlying tissues than in the vicinity of the chin.

Even if, in cases of carcinoma of the jaw which have broken through the infiltrated upper lip or cheek with their putrid, ulcerated surfaces, radical extirpation is rendered impossible, we still possess means and methods to lighten the sorry lot of the patient. The destroyed tissue may be removed widely with knife and scissors and the defect closed by a pediculated skin flap taken from the neck. The proposal of Garrès to cover ulcerated inoperable carcinoma, after the surface has been cleaned, with sound skin, is worthy of consideration, particularly in old persons, if any attempt at radical operation is out of the question. We have carried out this procedure with satisfactory results in a seventy-nine-year-old patient, for example, in whom a closure of the oral cavity was obtained through sliding a flap of skin from the neck.

RESECTION OF THE UPPER JAW

While partial subperiosteal resection suffices for the removal of benign tumors of the upper jaw, malignant neoplasms demand a complete or practically complete removal of half the jaw. Such a complete removal is indicated in sarcoma or carcinoma as soon as the diagnosis is established through clinical symptoms or from the microscopical examination of a small piece which has been excised, and so long as the tumor has not advanced too far over the soft parts of the face, as described in the previous section.

The extent of the resection of the soft parts and bone depends on the extent of the tumor. The hard palate, which is the floor of the antrum, is always removed in malignant tumors, while the muco-periosteal layer on the roof of the mouth may be preserved in case the neoplasm has not yet involved the palate itself. The bony floor of the orbit must likewise be sacrificed in the majority of cases, even if the eye as a result loses its support. The periosteum of the orbit should be carefully preserved, in so far as the neoplasm has not penetrated the bony wall.

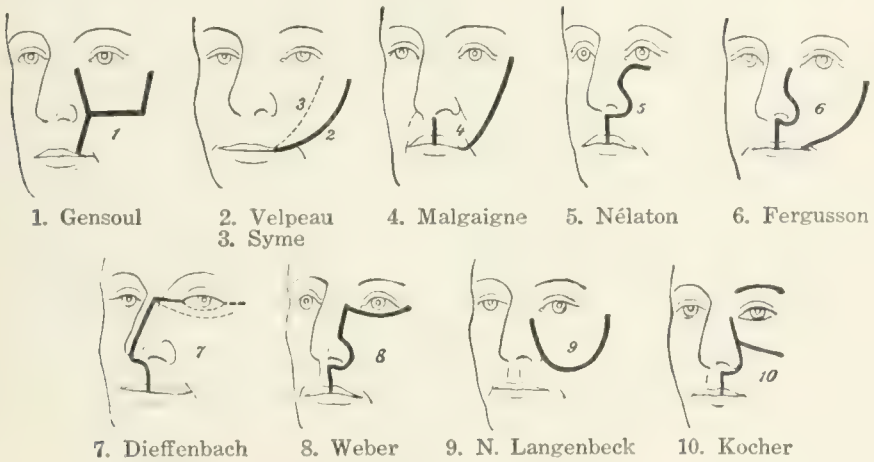
Resection of the orbital plate is not necessary in carcinoma and sarcoma of the alveolar process and in tumors which arise from the gum. As in these cases the synostosis with the zygoma does not have to be divided, the total resection which would otherwise be necessary may be replaced by a partial. How far finally the bony and mucous septa of the nose, the ethmoid cells, turbinates and portions of the frontal sinus may be preserved, must be decided in the individual case, particularly as these regions are frequently the source of widespread recurrence.

Since only an incomplete resection can be carried out through an intrabuccal incision, as recommended by Rotgans, this must be reserved for use in partial resection of the jaw. For complete removal a large external flap must be outlined on the cheek through which the jaw can be separated on all sides from its bony attachments. For purposes of comparison, we give in Fig. 301 a scheme of the various skin incisions which, to be sure, with the exception of the Weber incision and its modification according to Kocher, are for the most part no longer employed, but which under certain circumstances (in case the tumor involves the cheek or in case of sequestrum formation with fistulæ) may be used to some advantage.

The advantage of the Weber incision consists in the fact that it

runs in the skin fold between the lower lid, nose, lip, and cheek, and the scar as a result causes little disfigurement. The Kocher modification avoids the vessels, and particularly the facial branches to the lids, and the apex of the flap at the inner canthus is well supplied, while at times in the Weber incision there is danger of necrosis. If this occurs there forms as the result of scar contraction after the apex has sloughed away an annoying ectropion of the lower lid.

A total resection of the upper jaw is carried out in the following manner: The Dieffenbach-Weber incision begins at the inner canthus and runs in the fold of the lower lid along the lower margin of the orbit to a point opposite the outer canthus and then turns and runs parallel to the course of the branches of the facial nerve to the lid directly outward for 1 cm. Then starting from the same point,



1. Gensoul 2. Velpeau 3. Syme 4. Malgaigne 5. Nélaton 6. Fergusson

7. Dieffenbach 8. Weber 9. N. Langenbeck 10. Kocher

FIG. 301

Skin incisions for resection of the upper jaw.*

it is carried down alongside the nose to the ala, encircles this to the filtrum, and divides the lip near or directly on the ridge of the filtrum, together with the lip margin and the oral mucous membrane. The original Dieffenbach incision ran from the glabella down the ridge of the nose, then divided the inner, and if necessary the outer commissure of the lids. The flap comprising half the nose, the lower lid, cheek, and half the upper lip, was then freed from the underlying bone and turned to the side. The end result of the Weber modification is less disfiguring. The skin, wherever it is not involved by the neoplasm, is divided directly down to periosteum, and if possible down to bone. Spurting vessels are seized and tied,

* From Hochenegg, Lehrbuch der Chirurgie, Vol. 1, p. 367.

but other hemorrhage is controlled by pressure with gauze sponges.

After the flap is outlined it is dissected up from the underlying tissue, beginning at the nose and working outward toward the base of the flap. If the neoplasm has not penetrated the bone to involve the soft parts, the flap may be freed up subperiosteally with a raspatory. But in any place that is the least suspicious the periosteum must be left attached to the bone and the dissection continued with knife and scissors. The origin of the masseter muscles should never be freed by blunt dissection from the zygomatic process. In order to remove the upper lip with the cheek, the gum is incised hori-

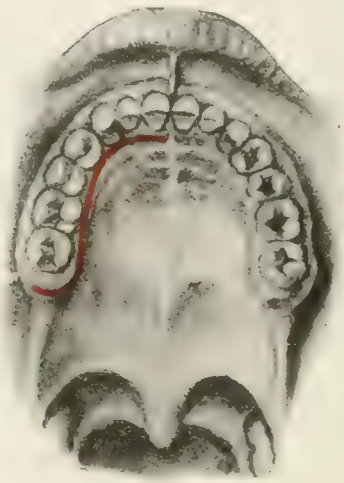


FIG. 302

Unilateral resection of the upper jaw; incision if the muco-periosteum of the hard palate is to be preserved.

zontally down to bone just above the tooth line, and finally the entire flap is turned outward on its wide base (Fig. 306, Plate 57).

Within the mouth a flap is made of the muco-periosteal covering of the bony palate corresponding to the cheek flap externally. But this muco-periosteal tissue can be preserved only if the neoplasm has not penetrated beneath it in any spot, and not the least suspicion exists of involvement of the oral surface of the bony palate. There is a distinct advantage for the patient in preserving this tissue, since by using it the nasal cavity can be thoroughly shut off from the oral cavity. This flap is freed up subperiosteally, starting from an incision that is carried along behind the alveolar process, and reaches from the last molar to the middle line (Fig. 302).

After freeing up this muco-periosteal flap, the soft palate is freed

transversely behind from the hard palate at its point of insertion with a knife. But if the muco-periosteal layer of the affected side has to be sacrificed, an incision is made in the middle line which extends backward to the insertion of the soft palate, and there turns at a right angle to follow the posterior edge of the hard palate to the last molar tooth (Fig. 303). If the soft palate is involved in the disease, it must likewise be removed, and the incision which runs down the middle of the hard palate must be prolonged through the soft palate to emerge at one side of the uvula (Fig. 304).

After the formation of the palatal flap, the upper jaw is freed from its bony attachments. First the orbital periosteum and the

FIG. 303

Unilateral resection of the upper jaw; incision for removal of the muco-periosteum of the hard palate.

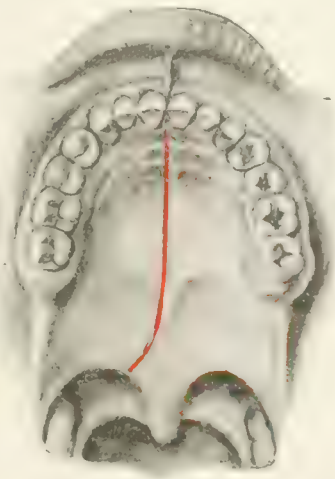


FIG. 304

Unilateral resection of the upper jaw; incision to include the soft palate.

mucous membrane of the nose are freed up (Fig. 306, Plate 57). In this process care should be taken not to tear the periosteum lining the orbit so that the bed of fat surrounding the bulb be not injured. The nasal mucous membrane, on the other hand, cannot be removed entire, but is likely to tear on the turbinates and the margins of the pyriform aperture. At this point, also, the nasal cartilage usually has to be separated from the bony margin with a knife. Injury of the nasal mucous membrane is usually without significance, so far as healing goes.

The first bony connection to be severed is the zygomatic process; this is done with chisel and mallet, or, as in the partial resection

of the upper jaw shown in Fig. 296, Plate 56, with the Gigli saw passed through the orbital fissure. Next, the frontal process and lachrymal bone are divided with the Liston bone-cutting forceps, and with the mouth open, the hard palate is divided from before backward with a sharp chisel (Fig. 307, Plate 57). If both incisors are present, the middle one is extracted to give an opportunity for placing the chisel. The bony palate may also be divided with the Gigli saw, a technique which is recommended particularly in tumors on the floor of the antrum which show a marked tendency to hemorrhage. For this purpose a catheter or Bellocque cannula is passed in through the nose and the end conducted outward through the mouth between the bony palate and the freed-up muco-periosteal layer. The saw is made fast to its tip by means of a silk ligature and the cannula withdrawn through the nose. Finally the synostosis of the upper jaw with the pterygoid process is destroyed by introducing a narrow chisel vertically behind the last molar or its empty alveolus (Fig. 307, Plate 57).

Now the jaw is seized with bone forceps and is twisted out, after cutting the last bridges of mucous membrane and connective tissue; or, after it is completely loosened, it may be pried out by an elevator introduced at the outer side. A smart hemorrhage, chiefly from the internal maxillary artery, is likely to follow the removal, but this may be controlled by seizing the large vessels with hemostats, and by packing off the others with gauze.

After the hemorrhage has been controlled the wound cavity is carefully examined and all suspicious tissue removed with rongeurs. The nasal cavity and the frontal sinus deserve particular attention. If the lachrymal bone or the ethmoid cells appear diseased, they must be removed, and likewise the frontal sinus must be cleaned out if the mucous membrane appears suspicious, particularly as recurrence in upper jaw carcinoma commonly arises here. The orbit, also, must be carefully examined for suspicious tissue, particularly in cases of sarcoma, and if involvement of the bulb or its surroundings is evident, an exenteration of the orbit must be performed. Permission for this procedure must be obtained in every case before resecting the upper jaw.

A packing of iodoform gauze is left behind in the wound cavity; its tip is carried out through the nasal orifice, and, beginning the fifth day after operation, it is drawn out a bit and shortened each day, until on the tenth day it is entirely removed. The skin wound

Resection of the upper jaw.

Fig. 305. Dieffenbach-Weber incision.

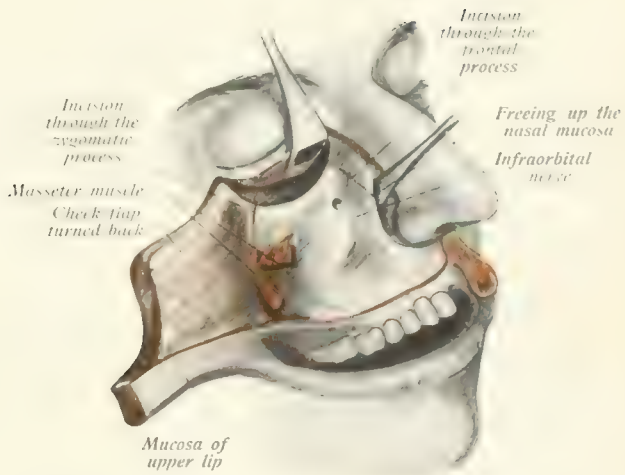


Fig. 306. Freeing up the cheek from the upper jaw.

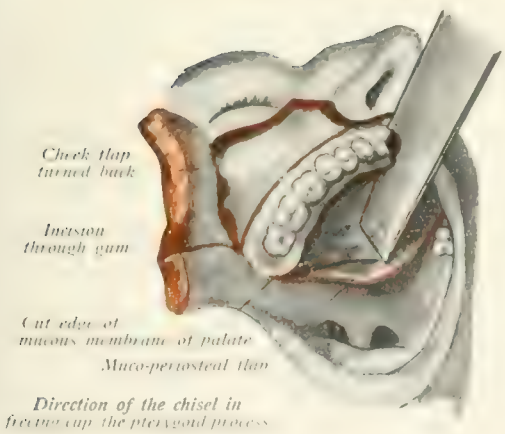

Cheek flap turned back
Incision through gum
Cut edge of mucous membrane of palate
Muco-periosteal flap
Direction of the chisel in freeing up the pterygoid process

Fig. 307. The hard palate is chiseled through in the middle line.

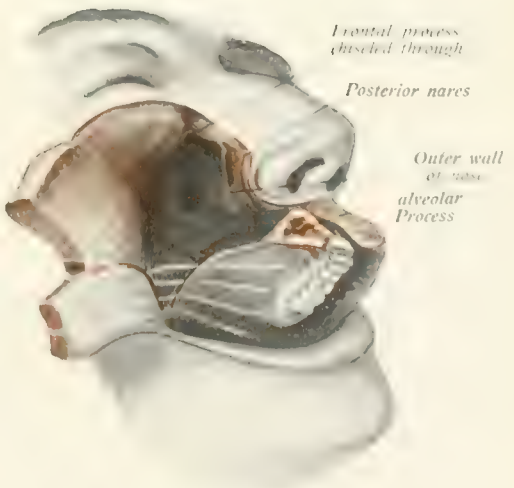


Fig. 308. Suture of palate to mucous membrane of cheek

is closed by exact approximation. Particular care is employed in the suture of lip and of gum, and judgment must be used in each case as to just how the mucous membrane of lip, cheek and gum are to be united (Fig. 308, Plate 57).

If the oral cavity cannot be closed off completely from the nose on account of extensive resection of the palate, a prothetic should be fitted into the defect by a skilled dentist. This may be done to the best advantage after the wound cavity has filled in with granulations. But one should not postpone the application of the prothetic too long, as difficulties may arise from scar contraction of the soft parts. The artificial restoration of the resected bone may be of advantage in other ways. If the orbital plate has to be removed, the eyeball sinks into the cavity. As the result there arise not only disturbances in vision such as diplopia, but also serious danger for the eye itself. In such case the prothetic serves also as a support to the eye.

But if for any reason one must give up the idea of artificial restoration of the upper jaw, one can follow the suggestion of Fritz König and create a useful support for the dropping eyeball by a plastic operation. The procedure consists in the formation of a pediculated flap from the temporal muscle and its insertion into the coronoid process, which is turned in toward the nose under the eyeball, and fastened to the frontal process of the upper jaw. The success of this plastic depends upon the observance of several conditions: the muscle flap must not be made so narrow as to endanger its nutrition, and a long piece of bone at the point of insertion of the muscle must be separated from the coronoid process without splintering, so that the muscle belly can be united to the frontal process of the upper jaw and remain in place without tension.

AFTER-TREATMENT

As the patient cannot swallow after resection of the jaw, he must at first be fed through a stomach-tube. Usually after a few days he gets so that he can take a little fluid through an invalid drinking-cup. If the suture of the palate holds and the oral cavity remains shut off from the wound cavity and the nose, the ability to swallow improves each day. Swallowing may be made much easier at first by holding a gauze sponge tightly against the defect in the jaw, against which the tongue may find a certain support. Disturbances of speech which are inevitable following the operation improve after the installation of a prothetic.

There may be considerable trouble from edema of the lower lid and conjunctivitis. Serious disturbances in the conjunctiva are avoided by protective bandages of borated vaseline and precautions such as already have been given for the prevention of keratitis after extirpation of the Gasserian ganglion (Volume I, p. 239). However, the swelling of the lids and irritation of the conjunctiva which follow this operation, as a rule, disappear only after several weeks.

Of disturbances in healing, mention should be made first of all of necrosis of the apex of the cheek flap at the inner canthus, the results of which as regards deformity of the lower lid have already been described. If on the day after operation the skin appears pale or of a bluish color, the stitches are to be removed in the vicinity to prevent extension of the local anemia. After removal of the iodoform packing, the remaining portion of the cheek flap lies against the wall of the wound cavity. In order to prevent retention within this large pouch, the wound is washed out daily after the iodoform packing has been removed, with lukewarm boric acid solution. If the secretion is considerable, the irrigation should be repeated several times during the day.

BILATERAL RESECTION OF THE UPPER JAW

Double resection is carried out in the infrequent cases in which a malignant neoplasm has proceeded from one side to involve the other. The incision in the skin is the same on both sides of the face as in the unilateral resection (Plate 57, p. 308). It begins at the inner canthus of one eye, passes down around the nose, and is carried up along the other side of the nose in similar fashion to end at the inner canthus of the other eye. Then an incision is carried below the lid on each side to the outer canthus, and from there it is extended laterally to a point about the middle of both malar bones. The two cheek flaps are loosened up and turned outward in the manner already described. The upper lip is divided on one of the ridges or in the middle line.

The division of the bone is carried out in the same order as in unilateral resection. The only difference is in the treatment of the hard palate, which, instead of being split along the middle, is removed entirely in connection with the bodies of the superior maxillæ. But in order to separate the nose from the bony palate, after cutting through the columna, a chisel is introduced horizontally at the lower margin of the pyriform aperture, dividing the septum

at the floor of the nose, or the anterior nasal spine; the cartilaginous septum and the vomer are divided with bone-cutting forceps. The freeing-up of the nose is completed by a vertical chisel cut on each side, dividing the nasal bones, and cutting in addition the perpendicular plate of the ethmoid, so that the nose is completely mobilized and can be turned conveniently backward onto the forehead.

The attainment of a satisfactory closure of the nose from the oral cavity from the point of view of swallowing and enunciation is more desirable even in bilateral resection of the upper jaw than in unilateral. If the neoplasm has avoided the hard palate, as large

FIG. 309

Bilateral resection of the upper jaw; Hildebrand's incision for preservation of the muco-periosteal covering of the hard palate.

FIG. 310

Bilateral resection of the upper jaw; Hildebrand's incision if the resection is to include the hard palate.

a portion as possible of its muco-periosteal covering is retained, and the incision is carried parallel to the teeth along the lingual side (Fig. 309). This joins the external incision, which is carried through the lingual and buccal mucous membrane for the purpose of freeing up the cheek flap behind the two last molars. After freeing up the muco-periosteal layer the soft palate is separated from the posterior margin of the bony palate in the manner described under unilateral resection, without injuring the mucous membrane. After the junction of the two pterygoid processes with the upper jaw have been chiseled through from within the mouth, the upper jaw may be pried out entire. If, finally, the margin of the palatal

flap is carefully sutured to the edge of the mucous membrane of the lip, an adequate closure of the nose from the oral cavity is obtained.

If extension of the neoplasm to the hard palate forbids the preservation of its oral muco-periosteal covering, the large defect may, nevertheless, be closed according to the method of Hildebrand. The preservation of the soft palate is necessary for this technique. The closure of the mouth from the nose is carried out by uniting the edges of the mucous membrane of the cheek in front to each other, and behind to the edge of the soft palate, forming a letter T (Fig. 311). Closure by suture in this fashion according

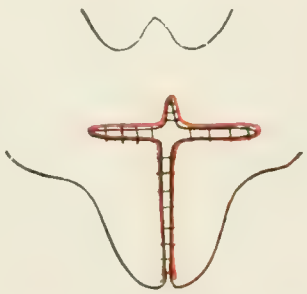


FIG. 311
Scheme for closure of defect after bilateral resection of the upper jaw, after Hildebrand.

to Hildebrand succeeds if the floor of the orbit has been removed on both sides, but it offers difficulties if it has been retained. In spite of the fact that the new roof of the mouth is very narrow, it accomplishes its purpose and makes clear enunciation and unrestricted swallowing possible.

CONTROL OF HEMORRHAGE

Case reports from various clinics show that the mortality of resection of the jaw is fairly high, on the average about 25 per cent. In addition to collapse as the result of loss of blood, we have to consider as cause of death, in the first place, aspiration pneumonia; less frequently, secondary hemorrhage; and exceptionally, purulent meningitis. These dangers are best met through prevention of an excessive loss of blood and the avoidance of general anesthesia.

Both of these requirements are satisfactorily fulfilled by the employment of local anesthesia, for it is possible by this means to operate painlessly and without loss of blood, and without paralyzing

the reflexes necessary for clearing the larynx and bronchi. According to Härtel,* anesthesia can be obtained through the direct injection of from 1 to 1½ c.c. (15 to 25 minims) of a one-half per cent. novocain-suprarenin solution into the Gasserian ganglion of the affected side, or through injection of both ganglia if the neoplasm has overstepped the middle line.

The conduction anesthesia obtained in this manner in the distribution of the trifacial nerve may be completed by a circumferential injection of the operative field on the cheek with a one-half per cent. novocain-suprarenin solution, which also induces a local anemia. The injection is made not only externally into the cheek, but the palate is also injected, or at least painted, with cocain. In order to lessen the psychic trauma of the blows of the chisel, the patient receives before operation a quarter grain of morphine. Scopolamin is never used, as it weakens the power of expectoration.

Those who hesitate at the technically difficult and somewhat dangerous injection of the Gasserian ganglion may induce anesthesia of the upper jaw after the older method recommended by Braun, which consists in breaking the conduction of the superior maxillary nerve and the nerves of the orbit. The first injection is made at the foramen rotundum; the directions for injecting the superior maxillary nerve have already been given on page 43 (see Fig. 1). Anesthesia of the lower half of the orbit is obtained by one injection on the medial side and a second on the external (Fig. 312, 1).

The needle is introduced on the medial wall on a level just above the horizontal plane which corresponds to the equator of the eyeball (Fig. 312, 3), in order to meet the ethmoidal nerve, and similarly on the external wall (Fig. 312, 2), so as to meet the zygomatic and the frontal branches. If the orbital plate of the superior maxilla can be preserved, it is not necessary to inject this. Fig. 312, after Braun, shows in addition to the points of introduction for conduction anesthesia of the nerves, the lines for circumferential injections for superficial anesthesia and anemia of the operative field.

The hard palate must be specially injected, not only on the labial and lingual sides of the alveolar margin, but also at the line of insertion of the soft palate and at the tip of the pterygoid process. Whether it is wise to exclude the important vomiting reflex by cocainizing the posterior wall of the pharynx can only be determined

*Härtel: Die Leitungsanästhesie und die Injektionsbehandlung des Ganglion Gasseri. Berlin, 1912.

after a great number of resections have been carried out under local anesthesia. But even if this reflex causes some difficulty during operation, the fact that it is intact has important significance in the prevention of aspiration and swallowing of blood.

When resection of the jaw is performed under general anesthesia, as it usually is, the intratracheal insufflation method should be em-

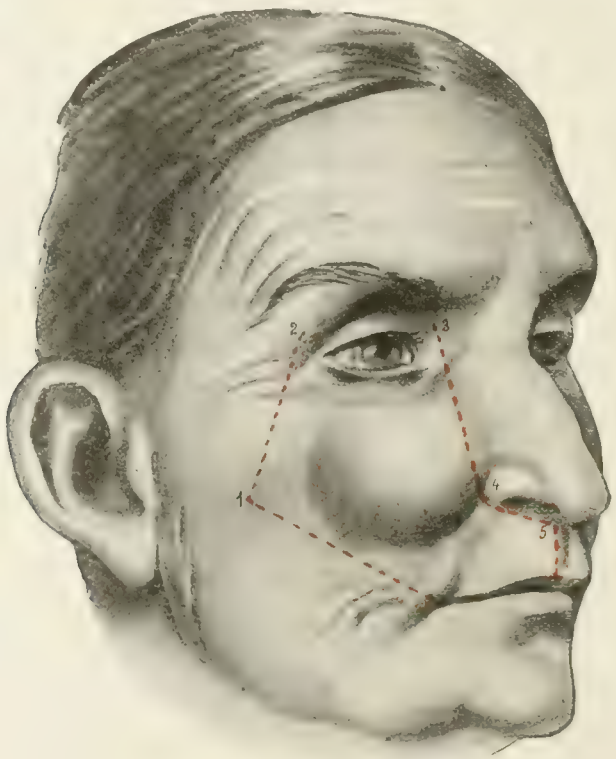


FIG. 312

1. Point for injection of the superior maxillary nerve at the foramen rotundum.
2. Lateral injection of the orbit for anesthetization of the zygomatic and frontal nerves.
3. Medial injection of the orbit for anesthetization of the ethmoidal nerve.
4 and 5 (as well as 1, 2 and 3) points for circuminjection of the cheek flap.

ployed (see p. 309). The operation is likely to be accompanied by considerable hemorrhage. On that account particular care should be taken while making the skin incision to clamp all spurting arteries at once and to prevent hemorrhage so far as possible through the use of gauze packing. The hemorrhage is likely to be particularly brisk during the process of dividing the bony connections and in prying out the superior maxilla after bone and tissue have been completely severed, particularly if a vascular growth has

Ligation of the external carotid artery.

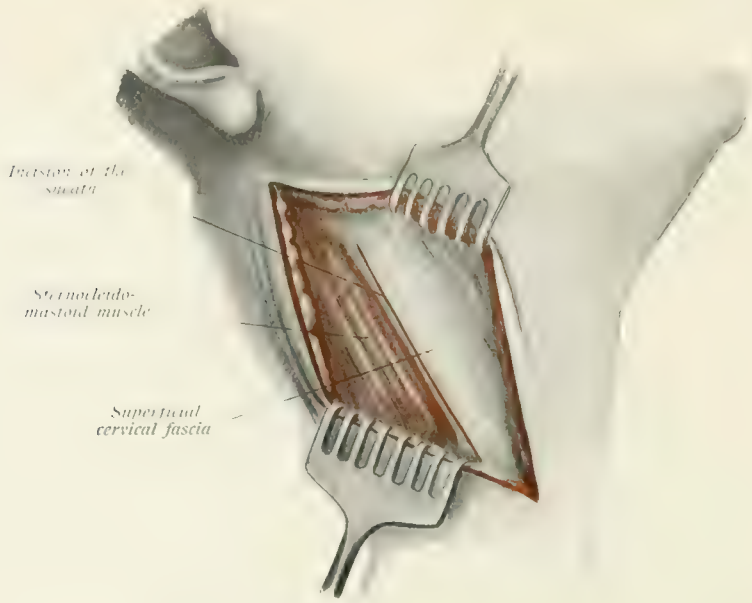


Fig. 313. Skin incision over the anterior margin of the sternocleidomastoid muscle.

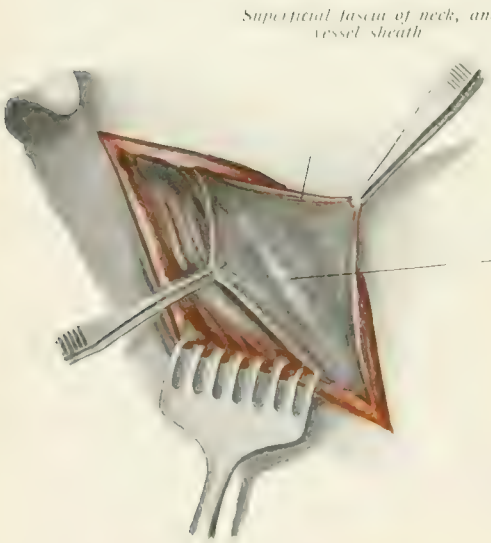


Fig. 314. Opening of the sheath.

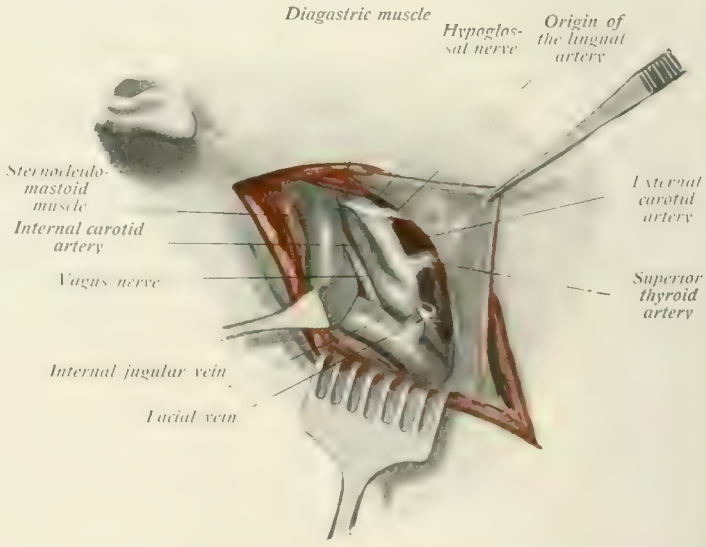


Fig. 315. Exposure of the external and internal carotid arteries.
(The descending branch of the hypoglossal is removed for the sake of clearness.

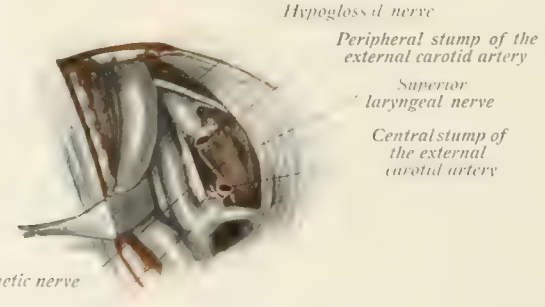

Hypoglossal nerve
Peripheral stump of the external carotid artery
Superior laryngeal nerve
Central stump of the external carotid artery
Sympathetic nerve
Common carotid artery

Fig. 316. The external carotid artery is divided between the ligatures.
(The internal carotid artery and the jugular vein are displaced backwards, rendering visible the sympathetic nerve.)

penetrated the bony wall of the antrum to the pharynx or nose. In such cases everything depends upon a rapid completion of the bony resection.

LIGATION OF THE EXTERNAL CAROTID ARTERY

Prophylactic ligation of the external carotid artery was first advised by Bryant and Kocher for the purpose of anticipating so far as possible the loss of blood; the technique is without danger if the ligature is not applied too close to the point of division of the common carotid. In order to create a truly bloodless field, Fritz König has recommended that the external carotid should be ligated above the superior thyroid, since this vessel anastomoses freely with the inferior thyroid and through this collateral circulation considerable hemorrhage may arise.

Through the incision necessary for tying the carotid the removal of diseased or suspicious nodes may at the same time be very conveniently carried out. One disadvantage, however, of the prophylactic ligation of the carotid lies in the not insignificant lengthening of the operation. Also as the result of the sudden drop in blood pressure, as a rule, an increase in venous hemorrhage is noticeable. Tying both carotids lessens the loss of blood considerably more than the unilateral operation, and this also has been recommended by Bryant and practiced by American surgeons.

In order to find the external carotid, the skin and platysma myoides are divided along the anterior margin of the sterno-mastoid muscle, with the head bent sharply backward and to the opposite side (Fig. 313, Plate 58). The incision begins at a point just above and behind the angle of the jaw, and extends downward to the level of the lower margin of the thyroid cartilage. The edges being retracted, the superficial layer of the fascia of the neck is divided along the anterior margin of the sterno-mastoid (Fig. 314, Plate 58), and the loose connective tissue which surrounds the great vessels and nerves is separated by blunt dissection parallel with their course, by smooth forceps and gauze. The veins which run transversely must be double tied and divided. The first large vessel which appears is the jugular vein (Fig. 315, Plate 58). If this is drawn back with a blunt retractor, there appears in the upper angle of the wound just below the posterior belly of the digastric muscle the hypoglossal nerve, which here crosses over the external carotid and its branch the lingual artery. Its descending branch runs

downward either in the fork between the external and internal carotids or farther backward on the posterior surface of the internal jugular vein.

When the loose tissue in the depths of the wound is finally dissected apart the big whitish vessel, the external carotid, appears, connected posteriorly and medially by connective tissue attachments with a second smaller vessel, the internal carotid. The latter, in contradistinction to the external carotid, has no lateral branches. In order to carry out the ligation of this vessel its anterior margin is exposed for the entire length of the wound, to accomplish which it is necessary to tie and divide a considerable branch of the internal jugular vein, the common facial vein. This vein crosses, as a rule, exactly at the bifurcation of the common carotid, which may be readily recognized by its bulblike contour. A few millimeters upward from this point a good-sized vessel takes origin, and this, on account of its anastomosis with the inferior thyroid, may be left intact below the ligature.

The external carotid is cleaned up all around between the lingual and the superior thyroid arteries, and is freed in particular from the internal carotid which lies in close contact beneath it. In this process the vagus nerve comes to view at its posterior margin, and usually somewhat behind. Only after these structures are clearly exposed should two medium-sized catgut ligatures be drawn through under the artery with a blunt aneurism needle and tied; finally, under tension from the two ligatures, the crumpled portion in between is divided (Fig. 316, Plate 58). The central strongly pulsating stump, as a rule, retracts immediately out of sight, so that in the space between it and the peripheral end the superior laryngeal nerve, and sometimes also the sympathetic nerve, are visible if the internal jugular vein and the internal carotid artery are displaced backward sufficiently with a retractor. Finally, the divided fascia is united with a few interrupted catgut sutures and the skin closed.

PREVENTION OF ASPIRATION

Another danger in resection of the upper jaw consists in the aspiration of blood and sputum, the sequel of which, pneumonia, causes a fatal termination in the majority of operated cases. A whole series of precautions may be considered for the purpose of meeting this danger, in addition to local anesthesia and its accom-

panying anemia of the operative field. The position of the patient during the operation is of significance from this point of view. Posture is definitely dependent upon the choice of anesthetic method; precautions for the prevention of hemorrhage and, finally, the resistance and age of the patient.

W. Rose recommended the supine posture with hanging head, the table being tilted so that the head is low. In this position blood and mucus flow by gravity into the naso-pharynx and run out through the nose. Köcher also favored this posture during operation, and he maintained it for several days after operation in order to prevent blood and mucus reaching the air-passages. However, the disadvantages of this posture are so great that it has never found general acceptance. As a result of the head hanging low, the venous bleeding is markedly increased, which interferes with the observation of the operative field. In our opinion the best position for resection of the upper jaw is the half-sitting posture, with the head bent slightly backward.

To prevent aspiration the patient is not kept deeply under the influence of the anesthetic for any length of time. Krönlein referred his more favorable results to interrupting the anesthesia immediately after completing the skin incision. During the freeing-up of the bony attachments and prying-out of the jaw, the patient remained half awake, and could immediately cough up everything that was aspirated. Krönlein based his recommendation of this rather disagreeable technique on the experience of earlier surgeons, who before the introduction of inhalation anesthesia seemed never to have been troubled with aspiration pneumonia following this operation. However, if local anesthesia be adopted, the question of inhalation anesthesia, as well as that of control of hemorrhage, are in large measure disposed of.

Local anesthesia and insufflation ether have limited the application of methods by which the deeper air-passages are cut off from the mouth and naso-pharynx with gauze packing. But since at times contraindications exist against the employment of local anesthesia, and for want of an expert anesthetist intratracheal insufflation cannot be used, these cannot be done away with entirely, and accordingly we will describe them briefly.

At the beginning of the operation the passage of blood into the air-passages may be safely prevented by packing the nasal cavity with gauze. After the patient is under ether a posterior packing

is first introduced by means of a Bellocque cannula, and then the nasal passages are packed anteriorly. But since this precautionary method does not suffice after division of the hard palate, in most cases of total resection of the upper jaw we do not depend upon packing the nose, but at the beginning pack the lower section of the pharynx and the entrance to the larynx tightly with gauze. In partial resection of the upper jaw the technique of Esmarch is still employed.

Shutting off the entrance to the larynx entirely by means of gauze can only be carried out if a clear air-way is maintained by means of a tracheotomy or peroral intubation. Both of these methods, which have been frequently employed in surgical procedures on the jaw or in the oral cavity, are lessening in popularity more and more nowadays as improved methods of local and general anesthesia are being adopted; nevertheless, they must be discussed.

Packing off the pharynx by the use of the ordinary tracheal cannula gives an insufficient closure, because the lower section of the pharynx and the entrance to the larynx with their pockets and irregularities allow only of incomplete packing, and frequently slight retching and swallowing disturbs the introduction. Then the blood can flow by the gauze and cannula into the trachea and bronchi.

Packing off can be accomplished with much more assurance by means of the *Trendelenburg cannula* or the *Michael compressed sponge cannula*, which find application not only in procedures within the oral cavity, but particularly in those on the pharynx and larynx. With the Trendelenburg cannula, a rubber ring attached around the tracheal tube is blown up after it has been introduced. This fits closely to the circumference of the trachea; but the rubber bag at times becomes permeable during the course of an operation, and allows the blood to flow down into the trachea. With the Michael cannula the closure is accomplished by means of a compressed sponge tied around the tube and covered with waterproof material, into which, just before its introduction into the trachea, water is squirted with a syringe, and the pressure caused by the swelling of the sponge is made use of.

With either cannula inhalation anesthesia may be carried out through a funnel, with gauze or flannel stretched across the top, attached to its external opening. Several considerations have been raised against both methods, and accordingly they are used but little.

In any operation on the upper jaw or involving the oral cavity, tracheotomy represents an additional procedure which may have serious consequences, for the sequelæ which follow the use of the tracheal cannula, tracheal catarrh, bronchitis and secondary pneumonia, occur even to a greater degree after the use of the much larger tampon cannula. And as with tracheotomy the ability to expectorate is lost, certain of those dangers which should be avoided are, in fact, encouraged by this protective agent.

Intubation of the larynx (Fig. 317), originated by O'Dwyer,

FIG. 317
Kuhn's peroral intubation.

by which a cannula of a proper size to fit the glottis is introduced into the larynx through the mouth, is to be considered as an advantageous substitute for tracheotomy. Kuhn originated a special instrument for *peroral intubation*, which consists of a long, flexible, spiral metal tube which is blunt and fenestrated at the end, fitted with a strong mandrin and various attachments for anesthesia and to hold the cannula against the cheek. For grown men, for women, and children, tubes are made of various sizes. Kuhn has changed and improved the instrument considerably in the last few years. Among other things he has tried dividing the cannula into parts so

that the anesthetic may enter with the air through one tube and through the other the tracheal mucus may be gotten rid of.

Although the larynx may be plugged more effectively by peroral intubation than with the tampon cannula, nevertheless the method has several drawbacks which stand in the way of its general employment, for in addition to the various local disturbances which develop in the larynx and trachea, sometimes accompanied by high fever, in the days following intubation, one is not always successful in introducing the tube between the vocal cords. The inexpert man is likely also to experience difficulty in pulling out

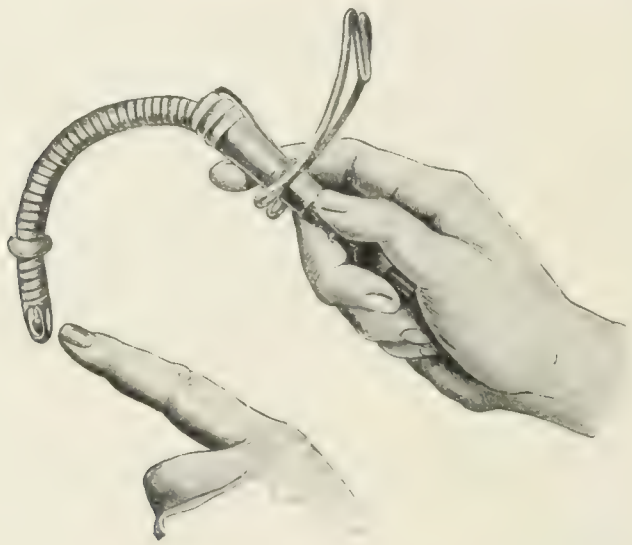


FIG. 318
Method of holding tube for introduction.

the mandrin after successful introduction of the cannula. In reference to the technique of peroral intubation we have followed the reports of Kuhn, and for additional details refer to his monograph.*

Before beginning the operation the patient receives from one-sixth to one-third of a grain of morphine hypodermically. The use of scopolamin is to be avoided on account of the cyanosis of the face which follows this drug. In addition, the pharynx, the posterior wall of the epiglottis, and when possible the inside of the larynx, is anesthetized with a sponge soaked in a 10 per cent. solution of cocain. The addition of a few drops of suprarenin increases and lengthens the influence of the cocain. Then, in order to bring

*Karger's Verlag, Berlin, 1911.

about a relaxation of the vocal cords and to loosen the spasm of the glottis aroused by the metal tube, the patient is deeply anesthetized.

As soon as this is accomplished, the operator, standing upon a stool and placing his left forefinger into the patient's mouth reaches the free edge of the epiglottis and lifts it up and forward. Guided by the forefinger, the cannula, armed with the sharply curved mandrin, is placed in the mouth and shoved forward between the vocal cords with its tip pointing anteriorly. A portion of the entrance to the larynx must be felt by the finger, the tongue being pulled to the opposite side, to prevent the tube being pushed into the lateral pouches or into the esophagus. It is not sufficient to reach the

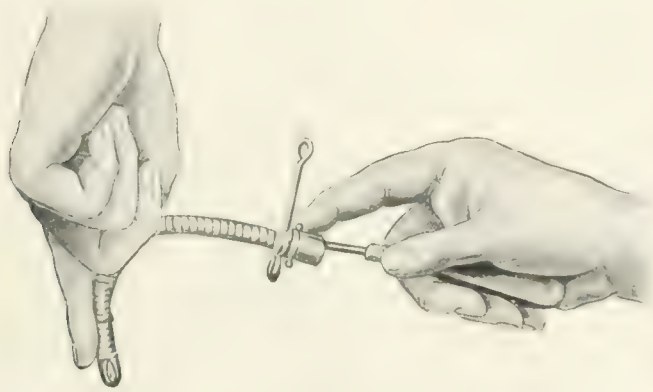


FIG. 319
Pushing the tube off the mandrin, first maneuver.

epiglottis with the tip of the forefinger, but along its lateral margins the arytenoid cartilages, and in front of these the lateral pouches, must be felt. In men with well-developed larynges this palpation frequently offers considerable difficulty; in women and children it is likely to be easier. When the forefinger has been rightly placed, it remains there until the cannula has been successfully passed through the glottis. Force should never be used in the introduction of the cannula, particularly if the intubation is not immediately successful.

The reasons for lack of success are that the epiglottis has not been lifted out of the way, that the tip of the index finger and, therefore, the tube was not in the right position, or that too large a tube has been selected for the narrow chink between the vocal cords. If a cramplike closure of the glottis is the cause of the

difficulty, one must wait for a deep inspiration to separate the vocal cords.

The proper introduction of the tube into the larynx can be recognized immediately by the blowing sound with which the air leaves the cannula on expiration. As soon as this is heard, the tube is held in place with the right index finger and the mandrin carefully drawn out; but in pulling out the mandrin the tube must be held fast with the finger. Better still, it is shoved off from the mandrin by means of the right little finger as the mandrin is withdrawn (Figs. 319 and 320), at the same time being gradually pushed farther in. Finally, the portion of the tube which lies freely movable in the mouth is pushed from its median position in the side of the

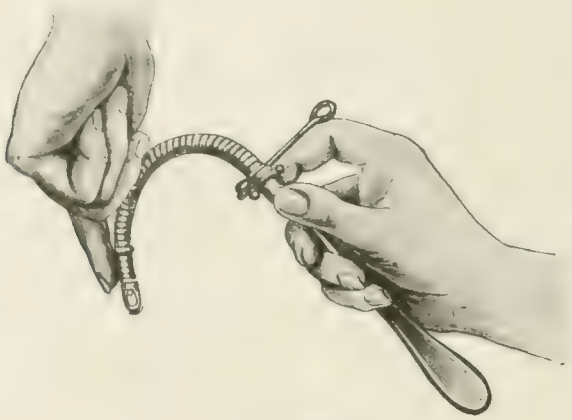


FIG. 320

Pushing the tube off the mandrin, the right hand creeps up on the mandrin.

mouth away from the operation. It is fastened in this place by a guard, which is held by two rubber bands going around the head, until the end of the operation. As soon as the intubation cannula is rightly fixed a metal tube carrying an anesthetic funnel is attached to its free end. This preparation can be carried on without danger of interruption of the anesthesia. If mucus collects in the tube, which can be determined by the gurgling sound which results, a fine catheter can be passed down the stiff metal tube and the secretion sucked out with an aspirating syringe. After the operation the tube is removed with a slight twisting motion, before the patient is fully out of the anesthetic.

INTRATRACHEAL INSUFFLATION OF ETHER

The intratracheal insufflation method of anesthesia, originated by Meltzer and first employed on human beings by Elsberg, of New York, and Ehrenfried, of Boston, has many advantages for procedures upon the jaw and oral cavity, as well as for intrathoracic surgery, for which it was first devised. It has been employed on several thousand cases and has demonstrated its value.

The chief difference between this method and that of Kuhn consists in the fact that a single thin lisle or soft-rubber catheter

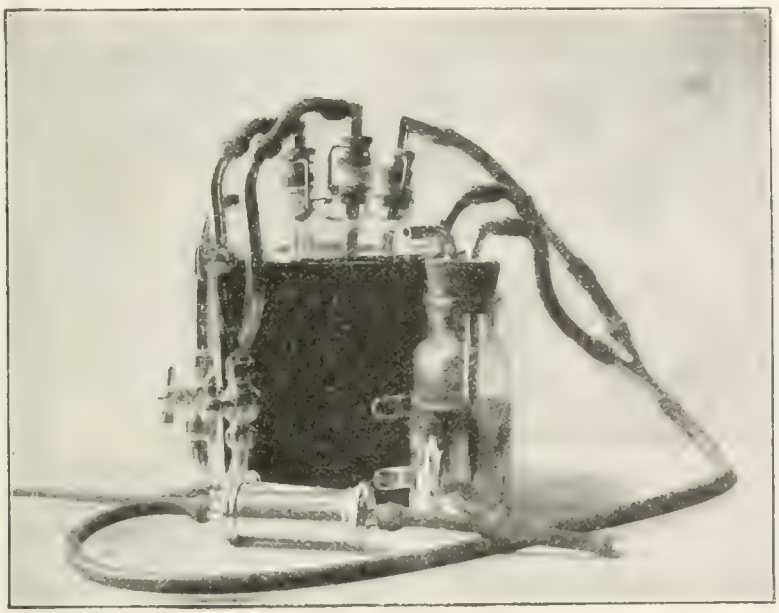


FIG. 321

Ehrenfried's apparatus for intratracheal etherization. (From Binnie's Surgery.)

replaces the larger but shorter metal tube. Through this tube air is continually being introduced under a pressure of about 15 mm. of mercury. In order to allow for expiration the tube should only about two-thirds fill the lumen of the trachea, but it must be introduced to a point just short of the bifurcation. Aspiration of blood in the space about the catheter need not be feared, since the trachea is under positive pressure just like the lungs, and, moreover, the glottis hugs the catheter tightly. The free outer end of the catheter is connected with a bellows or, in some devices, an electrical air-pump.

The apparatus of Ehrenfried (Fig. 321) represents the earliest

simplified form of apparatus.* It consists of a Wolff bottle with three necks, sitting within a copper water-jacket, which is filled with hot water, and a foot bellows. By means of cocks on the outside of the jacket, the stream of air from the bellows can be carried either through the hot water, over the top of the ether (contained in the Wolff bottle), or can be made to bubble through the ether when a particularly strong vapor is desired. This device allows the apparatus to be used also for intra-pharyngeal or intra-oral anesthesia, as desired.

Air and ether vapor can be mixed in any proportion. Connected with the delivery end of the apparatus is a safety valve and pressure regulator consisting of a bottle of mercury, into which a tube is plunged. The depth of the tube in the mercury, which is adjustable, represents the maximum of pressure which is allowed within the apparatus; if, for any reason, such as spasm of the glottis, the pressure should rise, the valve "blows off" automatically, and danger from interstitial emphysema is avoided. The apparatus is provided with a device to filter the air and to prevent droplets of condensed ether being carried over into the larynx. A clamp prevents the stoppers from becoming loose or blowing out of the bottle.

For an intratracheal tube one can use either a soft rubber or French lisle catheter. The latter is smoother and its walls are thinner in proportion to its diameter. It should be rendered pliable by being soaked in hot water before using. It is pushed in gently until resistance is felt, and is then withdrawn about an inch or more. Ordinarily in the adult a mark placed on the tube 26 cm. from the tip will lie against the teeth when the tube has reached a sufficient depth. The proper size for an adult is 21 French. The tubes should be sterilized by boiling, as formaldehyde or chemical disinfectants may cause local irritation.

The chief drawback to the general application of this method of anesthesia has been the difficulty in introducing the tube. Introduction under direct guidance of the eye has been generally employed, using the Chevalier Jackson laryngoscope. But this is a troublesome and time-consuming method, and involves shifting the patient into the Rose position on the table. Ehrenfried evolved a laryngeal forceps with sleeves attached for grasping the tube near its extremity (Fig. 322, *a*). With this one can acquire facility in

* See Ehrenfried, The Intratracheal Insufflation of Ether; British Medical Journal, Sept. 14, 1912.

guiding the tube into the larynx, with the mouth gag in place and the left forefinger on the epiglottis. For the soft rubber tube the introducer of Cotton and Boothby is used (Fig. 322, *b*). This is a cannula made on the same curve as the forceps, and through it the catheter is pushed.

Under this form of etherization the patient sleeps calmly, with suspended respiration, or breathing a few times per minute, depending on the volume of air delivered at the bifurcation of the bronchi, but maintaining good color and a good pulse. It may be continued for two hours or longer. Breathing is resumed immediately the tube is withdrawn.

The operator is at first somewhat disconcerted by the appearance of the patient, who lies upon the table motionless, with apparently

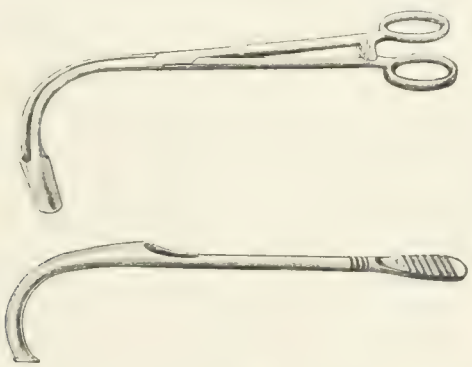


FIG. 322

Above, Ehrenfried's introducing forceps. Below, Cotton-Boothby introducing cannula, Ehrenfried's modification. (From Binnie's Surgery.)

suspended respiration, and without making a sound. But this is overcome by the advantages which the method offers in trained hands. Adequate ventilation of the lungs is assured. The air-passages are kept dry of mucus, and aspiration of mucus, blood, or vomitus is prevented by the return current of air about the tube, thus lessening the frequency of secondary pneumonia. No more ether is used than is needed within the lungs; the ether vapor is washed out with air as soon as the anesthesia is over, and therefore recovery is rapid; the chance of excess of ether or ether-laden mucus getting into the stomach is slight; accordingly recovery is gentle, with little vomiting. The tongue and jaw do not have to be held, and there is no danger of the glottis falling back and closing the trachea. Added to this is the great convenience, in operations

about the face, neck, and head, of not being hampered by the close presence and constant ministrations of the anesthetist.

RESECTION OF THE LOWER JAW

In the preceding pages the advantages, cosmetic and functional, that are offered in resection of the lower jaw by the preservation of a strip of bone to maintain the continuity of the arch of the jaw have repeatedly been demonstrated. In injuries, inflammatory affections, and benign tumors, the diseased mucous membrane, and under some circumstances the periosteum, are removed with knife or scissors, but only as much of the jaw-bone is removed with the chisel or bone forceps as is absolutely necessary.

For the most part, partial resections of the lower jaw can be undertaken through the oral cavity, but an external incision a finger's breadth below and parallel to the margin of the jaw is to be preferred on account of better wound drainage. The resulting disfigurement is not marked, particularly if the wound can be closed completely except for a small opening for the drainage-tube. To split the lower lip in the middle line and to loosen it from the bone for partial resection of the lower jaw is advisable only in exceptional cases; for instance, in sequestrotomy, osteomyelitis, or phosphorus necrosis. In such cases, also, the sub-mental incision has distinct advantages.

Defects of the mucous membrane of the mouth are closed by careful union of the mucous membrane of the floor of the mouth and of the sides of the tongue with the mucous membrane of the cheek. To accomplish this, mobilization and a plastic sliding of the membrane followed by suture may be necessary. Covering over the wound surface thus with a flap of mucous membrane and shutting it off from the oral cavity is of great significance from the point of view of undisturbed healing of the wound. The more surely and completely this succeeds, the more assuredly may infection of the wound and secondary necrosis of the exposed bone edges and soft parts be avoided.

In malignant tumors of the lower jaw, particularly sarcoma and carcinoma, cosmetic and functional results must be wholly disregarded, and stress laid on the radical removal of all affected tissue. Usually it becomes necessary to sacrifice the soft parts over a considerable area, and the jaw-bone either in all or part of its cir-

Resection of the lower jaw in continuity.

Fig. 323. Skin incision.

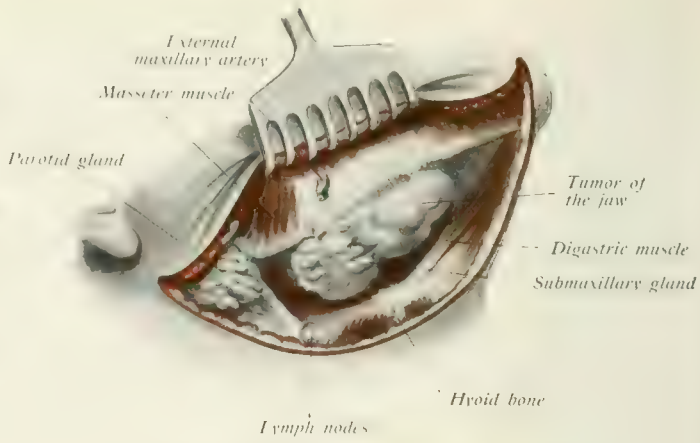


Fig. 324. Exposure of the submaxillary region.

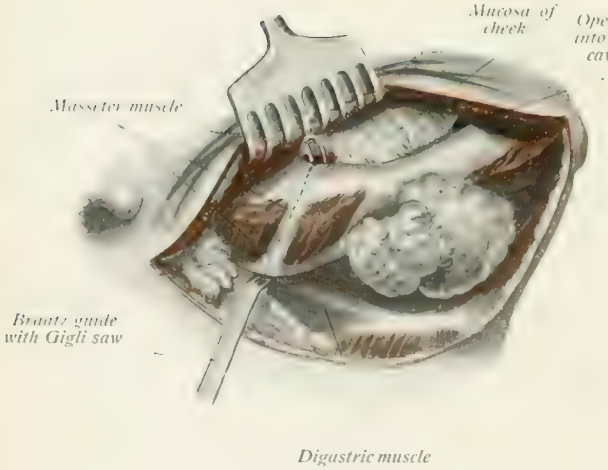


Fig. 325. Resection line at angle of jaw.

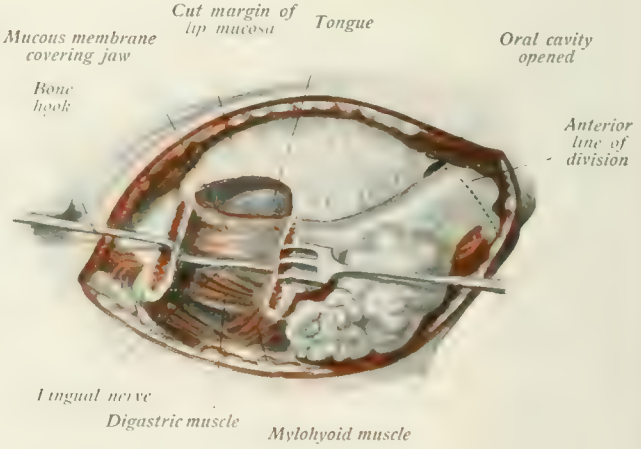


Fig. 326. The fragments are drawn apart.

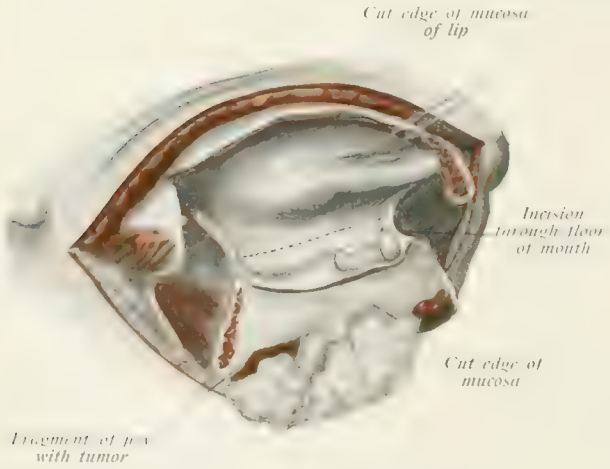


Fig. 327. Freeing the sawed out segment of the jaw.

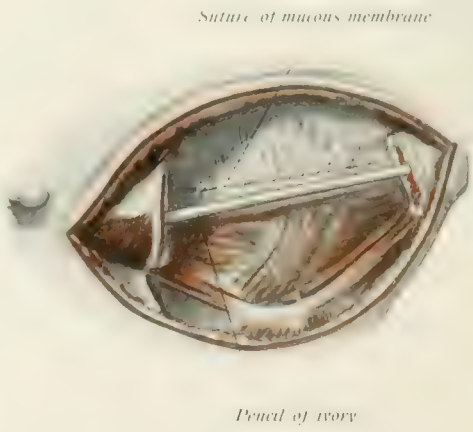


Fig. 328. Ivory prop in the dental canal.

cumference. The methods which are to be employed for this purpose may be represented by the following cases:

RESECTION OF THE LOWER JAW IN CONTINUITY

A thirty-nine-year-old laborer two years before entrance to the hospital had a tumor of the lip removed in his home town by a wedge-shaped incision. Without local recurrence in the scar, a tumor the size of a small apple had gradually formed at the lower edge of the right lower jaw in the few months preceding his entrance. This tumor was firmly attached to the bone, but the skin was freely movable over it. Within the mouth no roughness could be felt on the surface of the bone, and the mucous membrane was not adherent at any point. According to the report of the physician, microscopical examination of the tumor previously removed showed carcinoma. Accordingly the new formation was to be regarded as a metastatic carcinoma. For its removal resection in continuity of the involved portion was deemed necessary.

For the skin incision and dissection of the soft parts, the patient was carried as usual to full surgical anesthesia, but the rest of the operation was carried out under very light anesthesia, in order not to overcome the pharyngeal reflexes. For this reason, also, scopolamin-morphine was avoided.

With the patient half sitting, the head bent slightly backward, the skin incision was begun an inch behind the angle of the jaw at the anterior margin of the sterno-mastoid, and carried to a point at the chin the same distance from the margin of the jaw (Fig. 323, Plate 59). The lower facial branches, which supplied in part the affected half of the lower lip, could be avoided in this incision. At the middle line the incision turned upward over the chin and ended a finger's breadth below the vermilion border.

The wound edges were drawn apart with sharp hooks, the platysma myoides and the fascia of the neck divided from the angle of the jaw to the chin, and the deeper layers freed down to the margin of the jaw, in part by blunt dissection and in part by knife or scissors. At the angle of the jaw and at the chin this could be done without difficulty, but in the middle of the right half of the jaw care had to be taken in the dissection to avoid the tumor mass. During this process the facial artery was exposed, double tied and divided.

As the dissection was continued the submaxillary gland came into

view at the lower margin of the wound and was seen to pass over into the tumor mass without any distinct line of demarcation. Its lower margin and its posterior surface could be freed by blunt dissection from the digastric triangle as far as the inner surface of the jaw-bone, where a smart hemorrhage arose from the facial artery which ran out of the depths at the posterior margin of the submaxillary gland between the styloglossus and digastric muscles. As the gland was adherent to the tumor, it was decided to remove it. Upon further dissection the digastric muscle and the muscles of the floor of the mouth covered by fascia lay exposed behind and below it (Fig. 324, Plate 59).

After exposing the margin of the jaw, the upper flap was dissected up as far as the teeth. The tumor reached to within 2 cm. of the angle of the jaw, and here the insertion of the masseter had to be split (Fig. 325). In spite of this, in freeing up the cheek at this point the mucous membrane of the mouth was not opened. This was done only when the flap on the other side of the tumor toward the chin was separated from the jaw. The periosteum was left intact on the outer side of the bone from the angle of the jaw to the chin. Then the soft parts were freed up on the inner side of the jaw. Since the tumor had nowhere penetrated the bone, the periosteum could be preserved on this side in its entire extent. It was pried up in conjunction with the mucous membrane by means of an elevator, to the vicinity of the edges of the alveoli, where it was firmly adherent to the bone.

The resection of the portion of the jaw involved by the tumor, together with the suspicious tissue now fully exposed, began with a division of the jaw-bone in the region of the angle (Fig. 325, Plate 59). First the gum which was adherent without and within was divided at the level of the second molar, in this case absent, and an opening into the mouth wide enough to pass a Gigli saw was made. After the periosteum in the region of the masseter insertion was divided vertically and peeled backward a little, the muco-periosteal layer on the inner side of the jaw, which had already been freed up, was incised and a Braatz guide passed around the jaw from below. The saw was made fast, drawn through, and the bone divided. After the bone was sawn through the inferior dental artery spurted from the posterior cut surface. A Langenbeck hook was introduced in the bony canal and the fragments drawn apart (Fig. 326, Plate 59), but as the hemorrhage did not

cease, the canal was closed by beating together the spicules with a Passow chisel.

In order to examine carefully the mucous membrane of the mouth and to stop the flow of blood, the wound was pulled as wide open as possible and a gauze packing was introduced. This also protected the wound from contact with saliva during the further course of the operation and controlled the less active hemorrhage. The lingual nerve which came into view on pulling apart the fragments of the jaw was seized with a nerve clamp and twisted out.

The angle of the jaw having been sawn through, the bone was divided at the chin. For this purpose the middle incisor was extracted and the periosteum, in so far as this had not already been freed up with the skin flap, was incised around the bone. The Gigli saw broke, and the division had to be completed with a chisel. The left half of the jaw was drawn outward with a hook. The sawed-out portion of the jaw could not yet be removed since it was attached to the mucous membrane of the lip above, and to the floor of the mouth within. It was freed after dividing the mucous membrane of the lip above the gum, thus making a wide opening into the oral cavity. Thereupon the bony segment, together with the tumor, hung only by a narrow bridge of mucous membrane and a strip of muscle from the floor of the mouth (Fig. 327, Plate 59).

In order to divide these it was necessary, with the scissors, to connect the two wounds in the mucous membrane made in front and behind, for the passage of the Gigli saw. This incision through the mucous membrane of the floor of the mouth was made a few centimeters away from the bone. Before dividing the last attachments, that is to say, the insertions of the geniohyoglossus and the geniohyoid, a small piece of coarse silk was passed through the entire thickness of the tongue, which was pulled forward in order to prevent it from sinking back after its attachments to the chin were divided, with the possible danger of suffocation to the half-anesthetized patient. Then the resected segment of the jaw was pulled out with bone forceps and the muscle insertions were cut with scissors. The lingual artery which was divided in this process was seized just above the pulley of the digastric muscle and tied.

The extensive wound was then opened wide with retractors in all directions and all visible and palpable lymph nodes sought out and removed. Particular care was exercised in the region below

the chin, and externally in the neighborhood of the large vessels of the neck. Finally, the sawn surfaces of the bone were trimmed of all sharp spicules with rongeurs.

Thereupon the mucous membrane of the mouth was carefully united with catgut to the mucous membrane of the cheek and a complete closure of the mouth from the wound was obtained. This suture could be accomplished entirely without tension on account of the loose connection of the mucous membrane with the underlying tissues. In order to prevent the lower jaw, the continuity of which had been broken, from collapsing, a stick of ivory, 9½ cm. long, was introduced in place of the resected segment (Fig. 328, Plate 59). Its ends rested in the narrow canal of the jaw, and it formed a firm support on the one hand for the ascending ramus and on the other for the retained portion of the jaw. It kept the two portions in their proper relations to each other, and prevented the remaining lower teeth from falling back behind the uppers.

The large wound cavity was cleaned of all tabs of muscle and of connective tissue, in order to leave as smooth a surface as possible. Then the muscle stumps at the chin and at the angle of the jaw were sewn into the periosteum, and finally the skin incision was closed completely, except for the opening for a drainage-tube.

AFTER-TREATMENT

On the third day after operation the dressing was changed and the drainage-tube removed, but little wound secretion and no saliva or mucous having come through it. Apparently the mucous membrane suture had held. But fourteen days later a fistula formed at the point of drainage and some swelling appeared in the operative field; it was evident that the ivory pencil had not healed in without reaction. Accordingly, after the fourth week, the wound was opened and the pencil removed. This was indicated also by the fact that an X-ray showed that although the pencil was firmly seated at both ends in the bony fragments, nevertheless the short portion of the ascending ramus had been displaced backward and medially by muscle pull. As the result the left jaw was gradually coming over more and more to the right side. After removal of the ivory pencil the infiltration rapidly disappeared, and the secretion through the fistula diminished gradually until it closed up.

Immediately upon removal of the ivory pencil the Royal Dental Institute took over the treatment. By means of rubber supports from the upper to the lower jaw, the displacement of the left half of the jaw was gradually corrected. Shortly before discharge, two months after operation, a Sauer prothetic appliance was fitted to the left lower jaw; this, in chewing and talking, moved against the outer angle of the upper set of teeth and forced the lower half into proper relation with the upper jaw.

Examination six months later showed that the right half of the face had sunken in as the result of the extensive resection, and the cheek passed over into the neck without line of demarcation, but that the mouth and the left half of face were not disfigured or deformed. In closing the mouth a slight overcorrection was obtained as the result of the use of the prothetic. The patient could talk clearly, although with a slight impediment, and could swallow and chew without difficulty. There was no evidence of recurrence.

SUBPERIOSTEAL AND EXTRA-PERIOSTEAL RESECTION OF THE JAW

In the foregoing case the periosteum on the inner side of the jaw could be partly preserved, but on the outer surface it had to be removed entire. Thus in many cases a sharp differentiation between subperiosteal and extra-periosteal resections cannot be made. A resection can never be completely subperiosteal, because at the apex of the chin and at the angle of the jaw, muscle insertion, periosteum, and bone are practically inseparable from each other. While one can usually preserve the periosteum intact in resection for inflammatory disease and in benign neoplasms, this is not allowable in malignant tumors, for self-evident reasons.

The preservation of the periosteum is of the greatest significance, for the prevention of marked disfigurement. It can serve as a source of new bone formation and thus lead to restoration of the arch of the jaw, which is of great advantage for cosmetic and still more for functional purposes. Also if the periosteum is retained, transplanted portions of bone heal in with more assurance, and even if no bone forms in the periosteum which has been left behind, prothetics, which are supplied later, find in the hard callus-like cord which forms as the result of the combination of periosteum and scar tissue a much firmer support.

EXARTICULATION OF ONE-HALF OF THE LOWER JAW

In resection in continuity, as in the foregoing example, one should always preserve enough of the ascending ramus to successfully support an ivory pencil or a peg of bone. The friable bone of old persons splinters badly, particularly if a chisel is employed, sometimes even into the incisure, so that it then becomes advantageous to exarticulate the remnant of the ascending ramus and later to replace the lost half of the jaw by a prothetic. If for this reason

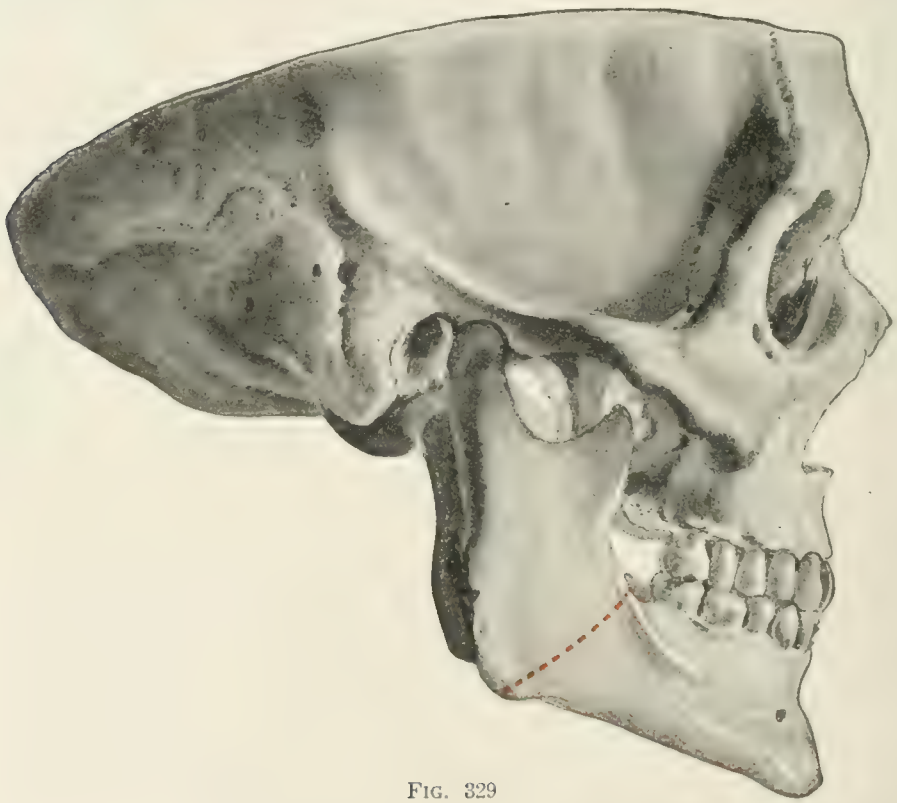


FIG. 329
Limit for resection of the jaw in continuity.

or because of the extent of the malignant disease, less than half of the angle of the jaw can be retained (see Fig. 329), one should perform a unilateral exarticulation instead of a resection in continuity, with the preservation of one or more useless splinters of bone.

Autoplastic transplantation of bone, or a prothetic, gives better results than a short fragment of the jaw which is continually being drawn out of its normal relations by muscle pull. The following case will give an idea of the way this procedure can be carried out.

Exarticulation of one half of the lower jaw.

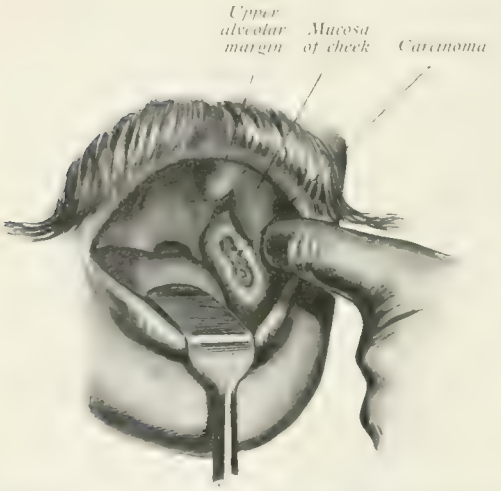


Fig. 330. Tumor on alveolar margin of lower jaw.

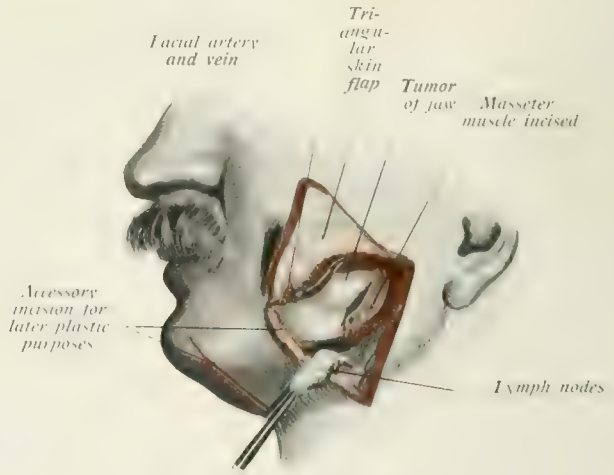


Fig. 331. Incision.

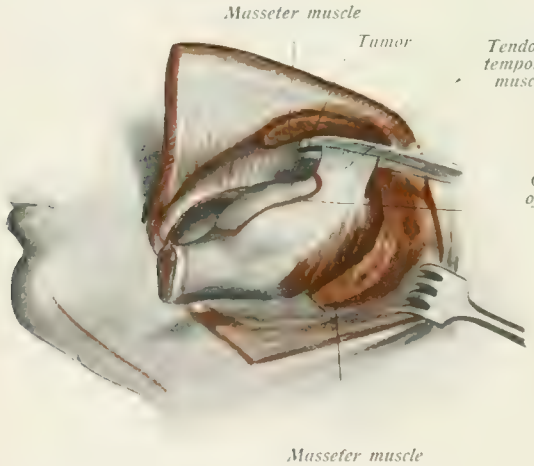


Fig. 332. Opening of the oral cavity and resection of the tendon of the temporal muscle.

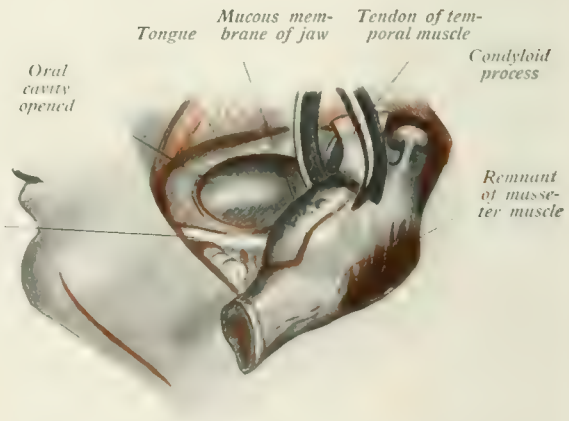


Fig. 333. Temporo-maxillary exarticulation.

Fig. 334. Wound after completion of the exarticulation.

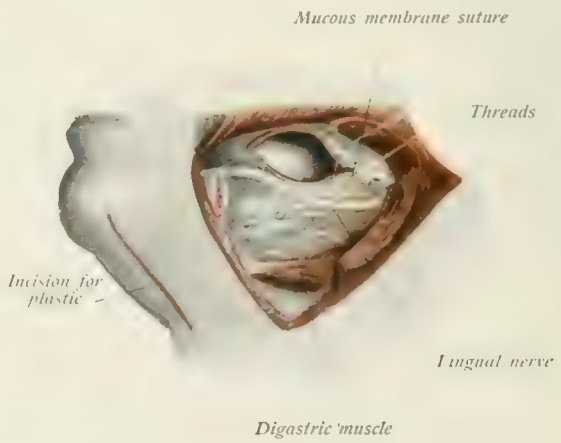


Fig. 335. Suture of mucosa of cheek.

A sixty-eight-year-old man with a tumor of the lower jaw had noticed two years before entrance, a small mucous ulcer in the back part of the mouth upon the margin of the left lower jaw, which had gradually grown and had reached the length of a phalanx. The bone in this region gradually enlarged. The edge of the ulcer was hard to the touch. The gum in the neighborhood was thickened and the entire growth was firmly adherent to the margin of the jaw (Fig. 330, Plate 60). It was undoubtedly a mucous membrane carcinoma, which had involved the lower jaw.

To remove all of the diseased tissue the left half of the lower jaw had to be exarticulated. The incision was planned so that the resected bone could be replaced by a pediculated bone and tissue flap from the margin of the portion of the jaw which remained. With this intention two parallel incisions about two inches long were made on the median side of the tumor, running downward and backward from the margin of the jaw. From the posterior of these incisions a triangular flap was formed externally, and turned upward (Fig. 331, Plate 60). This was done having in mind a later skin sliding plastic according to the principle of Dieffenbach (see p. 123).

On freeing up the triangular flap and exposing the upper margin of the jaw the facial vein was double tied and divided. After splitting the anterior edge of the masseter muscle, the external aspect of the tumor was exposed, reaching almost to the angle of the jaw. At the lower margin of the jaw all visible and palpable lymph nodes were dissected out and removed, together with the submaxillary gland, in the typical fashion. A blunt dissector was passed around the bone at the anterior end of the wound, a needle carrying the Gigli saw followed it, and the jaw was sawn through. The ends of the bone were drawn apart on Langenbeck hooks, and the soft parts were freed for a considerable distance from the focus of disease. Surrounding the ulcerated surface, and for some considerable distance about it, the mucous membrane of the jaw had to be sacrificed, and the oral cavity was thus opened wide (Fig. 332, Plate 60).

Thereupon the upper edge of the now completely divided masseter muscle was retracted strongly upward, and the inner surface of the jaw was freed from the other muscles of mastication. The internal pterygoid muscle, which inserts on the inner aspect of the angle of the jaw, was divided. Then the ramus of the jaw, the attached soft

parts having been divided and the wound edges sharply retracted, could be seized with bone forceps and dislocated outward. Then it became evident that the neoplasm had infiltrated the bone so far upward that only a short fragment of the ramus could be preserved. The ramus hung finally by the capsule of the joint, and by the tendon of the temporal muscle, which was now separated from the coronoid process (Fig. 332, Plate 60).

The inferior dental nerve lay exposed on the inner aspect of the ramus at its point of entrance into the inferior dental canal; it was seized and, in order to prevent involvement in the scar, was twisted out in the ordinary manner. Then to free it from its last attachments, the jaw was seized high up with bone forceps and slowly rotated out (Fig. 333, Plate 60). The joint capsule was incised with a knife on its external surface only in order to prevent injury to the internal maxillary artery, which at this point lies close behind the capsule. Some bleeding from the inferior dental artery still persisted, but it could be easily controlled by pressure with iodoform gauze.

After resection and exarticulation of the jaw, and the removal of all lymph nodes as well as the submaxillary gland, the large wound cavity with the lingual nerve and the opening in the mucous membrane lay completely exposed (Fig. 334, Plate 60). It was now important to close the oral cavity as completely as possible, and accordingly the opening in the mucous membrane was sutured with catgut (Fig. 335, Plate 60). This suture could be applied without tension after the mucous membrane of the jaw in the neighborhood was separated from the underlying tissue and mobilized. After completion of the suture, the defect in the jaw was immediately replaced by a flap of skin and bone, a procedure of which we will give the particulars later (see p. 327).

CONTROL OF HEMORRHAGE AND PREVENTION OF ASPIRATION

Neither in cases of the sort just cited nor in resection or exarticulation of the lower jaw do we recommend the preliminary ligation of the external carotid artery, as advised particularly by Kocher and Fritz König. To control hemorrhage, it suffices to double tie and divide each vessel as in other operations. The terminal branch of the external carotid, the internal maxillary artery, is the only vessel which may cause serious hemorrhage, if injured at the end of operation. Ligation of this artery is often incon-

venient, particularly if the vessel has been cut accidentally and has retracted into muscle. But it can usually be done without real difficulty, as we have repeatedly observed in sawing through the jaw for the exposure of the third division of the trifacial nerve. One must remember that it zigzags between the muscles of mastication at a point slightly below the level of the articulation of the jaw, and then lies external to the external pterygoid just behind the joint capsule.

In resection of the jaw, injury of this vessel does not often occur, and it may be avoided readily in exarticulation if the capsule is not cut on its median side but instead the condyles are twisted out after dividing the outer half of the capsule. If serious bleeding occurs in a tumor which extends upward for some distance, the external carotid may be readily tied through the lower end of the skin incision if the lower wound margin is forcibly retracted downward. In this case the section between the superior thyroid and the lingual arteries is chosen as the most practicable for applying the ligature.

Such ligation in no way helps control the venous bleeding from such tumors, and in extensive sarcoma of the jaw this is to be feared as much as arterial hemorrhage. For example a patient in whom at the first sitting glandular metastases lying along the great vessels of the neck were removed and tied off, died on the third day following this procedure as the result of a profuse venous bleeding which suddenly arose in the tumor. On pathological examination, the maxillary artery was found to be completely closed by tumor thrombi, but the venous spaces were everywhere markedly enlarged and still contained fluid blood. Tying the carotid artery would have been of no avail.

Nor is preliminary ligation of the external carotid necessary for the prevention of aspiration of blood. This danger is slight if one follows the rule to keep the mouth closed as long as possible and to open it only for examination of the wound and to get access to the cavity. If blood threatens to flow from the wound into the mouth and pharynx, it can be removed immediately with sponges if the operator and his assistants exercise sufficient care. Moreover, aspiration may be decreased if after the mouth is open the anesthesia is lessened and the operation is finished under a superficial stage of anesthesia in which the cough reflex at least is retained.

TOTAL EXARTICULATION OF THE LOWER JAW

The removal or exarticulation of the lower jaw *in toto* has been performed in a considerable series of cases. Erkes and Ernst * have collected the reported cases. The skin incision is not different from that used in the unilateral resection or exarticulation, except that the incision lying below the margin of the jaw on both sides must meet in the middle under the chin. It is useless to split the lip and the chin in the middle line for removal of the entire lower jaw; for through the effect of muscle pull upon the line of suture, and as the result of constant pressure from the necessary prothetic within the mouth, necrosis and fistula formation and even separation of the skin from the floor of the mouth are easily induced. But if it offers any technical advantage the jaw-bone may be sawn through in the middle and each half exarticulated by itself in the manner already described.

Since after total resection of the lower jaw the floor of the mouth and to a certain degree the epiglottis lose their support and cause danger of suffocation to the patient, a prothetic substitute must be prepared beforehand on which the tongue and the floor of the mouth may at once find support. It is necessary in such operations to have the advice and constant assistance of a dentist who is an expert in the preparation of prothetics. He may at the same time have charge of the preparatory treatment of diseased teeth in order to prevent the extensive wound, full of pockets and recesses, from becoming infected through them.

An indication for total resection of the lower jaw is extensive destruction of the bone by malignant disease, in which radical removal or the preservation of only a portion of one or both ascending rami can be considered. In such a case loose fragments of the rami are of no use for holding an extensive prothetic appliance, as they become badly displaced from the pull of the muscles of mastication. From the point of view of the prothetic and later mobility of the artificially supported lower half of the face, exarticulation is more efficient than the preservation of the joints. It is important, moreover, to preserve the muscles of mastication on both sides as far as possible, particularly the pair of muscles which run in practically the same direction, the internal pterygoid and the masseter, for in the pocket between the masseter without and the pterygoids within, the temporary prothetic is to be fitted, and later it is to find a permanent and solid support on their scarred walls.

* Deuts. Zeits. f. Chir., 1912, Vol. 118.

ARTIFICIAL SUBSTITUTES FOR A RESECTED JAW

After resection in continuity from the body of the jaw, or after exarticulation of one-half, the remnants of the jaw are drawn inward out of all their normal relation by the pull of the muscles of mastication and the muscles of the floor of the mouth. The lower set of teeth are gradually displaced backward behind the upper, and the edges of the two sets do not meet either in rest or in active closure of the jaw, so that the ability to chew is lost.

In resection of the middle segment the tongue and hyoid lose their support, and this occurs even in unilateral exarticulation, with gradually increasing dislocation of the other half of the jaw, at times even after the muscles of the floor of the mouth which insert in it have had to be partially divided. As results of this retraction of the floor of the mouth and tongue there arise a mechanical closure or narrowing of the entrance to the larynx, loss of ability to chew, and disturbances of swallowing and talking. It becomes necessary, therefore, after resection of the lower jaw, to prevent backward displacement of the fragments and particularly of the tongue, or if this has not been done in the first place, it should be corrected later on. Even at the end of the second week after resection, the muscles of the floor of the mouth, tongue, and cheek may be so contracted that the dislocated portion of the jaw can no longer even be brought back into its normal position. Later, correction becomes still more difficult as the result of scar contracture of the muscle, deformation of the distorted articulation, and the contraction of the capsule.

It becomes necessary, therefore, less for cosmetic than for functional reasons, to restore the broken arch of the jaw by the introduction of a stiff bridge. This may be done through prothetics which find their support on the remnants of the jaw which remain, or upon the upper set of teeth; or pieces of bone or strips of other non-absorbable material may be operatively fitted into the defect and allowed to heal in place.

TREATMENT BY PROTHETICS

The fitting of a prothetic demands the co-operation of an experienced dentist, who must make a cast of the jaw before operation, in order to prepare the prothetic in advance. After resection the conditions for some time forbid taking a cast of the mouth and

such other necessary handling. According to present-day views a temporary prothetic should be introduced immediately after the operation is finished, and it should be kept in place during the first few weeks until healing is complete. Then it is removed and replaced by a final prothetic. The introduction is made regardless of the condition of the wound, for instance without reference as to whether the wound has been closed within by suture of the mucous membrane, or if openings have been left, either for carrying off the wound secretions or because of lack of the plastic material necessary for closure. The dangerous dropping back of the remaining portion of the jaw and all the disadvantages which this involves are prevented by an immediate prothetic.

The choice of prothetic depends upon which portion of the jaw has been resected; whether the middle segment has been removed, whether one-half has been exarticulated through the joint, or whether a portion of this has had to be resected. The simplest technique to hold the stump of the broken arch of the jaw-bone in its normal position consists in fitting in a bar between the two fragments. Sauer used for this purpose two pieces of iron wire bent in the form of a bow which ran along the teeth within and without and was held in position by a fine material twisted in and out around the neck of the teeth. According to Hahl, the same may be accomplished by impaling a metal rod into the fragments.

Partsch employs a somewhat wider strip of white metal which is bent to fit, and for drainage purposes is punched with holes. This he fastens by suture to the ends of the stumps. As shown in the case already described (see p. 316), a stick of ivory or a bone knitting-needle may serve the same purpose. But the Sauer wire, as well as all prothetics fastened to the teeth, have the disadvantage that in time they loosen the teeth and the contrivance thus loses its support.

The employment of these simple methods is limited to lateral defects of the jaw, while the restoration of a resected middle portion may be accomplished through wider prothetics. For with the removal of this portion of the arch of the jaw, the chin loses its support completely. A straight strip between the two stumps will prevent their displacement backward, but it results in a considerable disfigurement through loss of the natural projection of the chin.

In order to maintain the projection of the chin and to avoid dangerous displacement of the fragments after the resection of the

middle portion, the immediate prothetic introduced by Claude Martin, or one of its numerous modifications, is employed. The Martin prothetic is made similar to the resected portion of the jaw and consists of a piece of hard rubber bent into the form of a chin, which, at the end of the operation, is screwed fast into the two stumps. Schröder introduced this prothetic into Germany and improved it. As one cannot say beforehand how big the defect will be, these hard rubber prothetics should be made too large rather than too small; they may be cut down to fit at the time of operation. The prothetic has numerous holes and canals for carrying off the wound secretions. As soon as the wound within the mouth has formed a firm scar, the provisional prothetic which lies outside the mucous membrane is removed and replaced by the permanent one, which has been measured for beforehand, and is fastened over the lateral remnants of the alveolar processes.

The modifications of this Martin prothetic consist particularly in the choice of various sorts of metal in place of hard rubber, which becomes rough as the result of the influence of the wound secretions, and retards the cleaning up and healing of the wound. Various men have used porcelain, aluminum, or other metals for the provisional apparatus.

After exarticulation of one-half of the lower jaw the retraction of the other is prevented on similar principles to those used in resection in continuity. The immediate prothetic is replaced later by a permanent one. One end is made fast to the fragment of the jaw and the free end reaches into the glenoid fossa of the temporal bone. Claude Martin, who also originated this exarticulation prothetic, selected hard rubber as the material, and this is still used in the majority of cases. Schröder has had models of this type made in various sizes, to imitate the ascending ramus with its articular process, and these may be purchased of the surgical supply houses. For carrying off the wound secretions the apparatus is provided with a channel and several holes. The joint end is rounded off and is somewhat broader than the remaining portion, in order that it may remain in the region of the joint socket more readily and with less pressure.

The choice of these prothetics is completely independent of whether or not the mucous membrane can be closed at the end of the operation. Commonly the wound, on account of the wide opening into the oral cavity, becomes infected, particularly if a large area of the

floor of the mouth has had to be removed on account of the extent of the neoplasm. In spite of this the prothetic fulfills its purpose, and causes less disturbance in healing than would be expected from so large a foreign body. The cavity in which it lies in time fills in with granulations, and succumbs gradually to the scar contraction. Meanwhile it is important to take particular care that drainage is unrestricted. The healing of the wound is promoted and the rather ungainly immediate prothetic may be replaced earlier by the lighter permanent prothetic, if one has in the first place succeeded in uniting the mucous membrane below the prothetic by exact suture, so that this lies within the mouth and for the most part outside the wound cavity.

The permanent prothetic is made fast just like the temporary one, or it may be carried by a dental bridge or by a hard rubber plate. Usually under the lighter and less irritating final prothetic, the fistulæ which remain open at the time of its insertion cease discharging and close up. Perthes advises waiting until the scar contraction at the floor of the mouth is complete, at least two months, before introducing the permanent prothetic.

Fritz König has made use of a stout bridge of ivory, cut to imitate the resected portion of the jaw, for those cases in which the mucous membrane has been closed exactly, and infection seems unlikely. According to his instructions, this inset should not be too light. In resection of the chin the corresponding ivory bridge is rammed at both ends into the wound cavity, but in replacing the ascending ramus, the anterior end is made fast this way, and the posterior is fitted into the neighborhood of the articulation. Tillmann replaced the resected portion autoplastically by a strip of bone and periosteum from the tibia. Although in both his cases the course was not aseptic, but fistulæ formed through which sequestra were thrown off, nevertheless the piece of bone finally healed in satisfactorily.

If for any reason an immediate prothetic cannot be introduced, the retraction of the remaining half of the jaw may be prevented by the use of a Sauer apparatus. This consists of a metal plate directed obliquely upward and outward, which is made fast to the teeth of the remnant of the jaw by means of crowns and wires or by means of a sublingual prothetic. In closing the jaw, and particularly with every attempt to chew, it slides along the teeth of the upper jaw and forces the lower jaw outward into its proper position. It finds application not only in unilateral exarticulation, but

Plastic resection of the lower jaw according to F. Krause.

Fig. 336. The guide is passed along under the jaw.

Fig. 337. Sawing out the strip of bone.

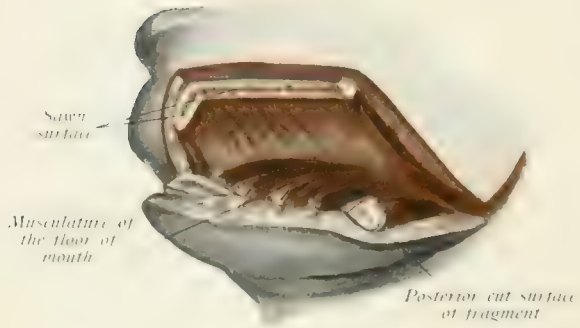


Fig. 338. Muscle is sewn over the sawn surface of the fragment.

Fig. 339. The bony transplant is fixed in its new position.

Fig. 340. The sawn surface left behind is covered with muscle.

Fig. 341. Closure of the wound.

after resection in continuity, when in spite of the implantation of a bar one fragment of the jaw begins to yield. It is employed also to correct contractures already formed after resection of the lower jaw as well as after fractures, and in that case it is made fast on one or both sides to the remaining teeth. If there are no more teeth present, the Sauer apparatus may, according to Hahl, be fastened to a prothetic on the floor of the mouth or on the gum. The disadvantages of this apparatus consist in the continued rubbing of the metal surface on the edges of the upper teeth, and in the incompleteness and weakness of the act of chewing.

KRAUSE'S PLASTIC RESTORATION OF THE RESECTED LOWER JAW

Ordinarily after resection of the lower jaw, an entirely satisfactory result, both as regards function and appearance, is obtained with the help of a prothetic fitted by an expert dentist. Treatment by prothetics has accordingly become the method generally employed after loss of a section of the jaw either through resection or injury. But experience has shown that it is not sufficient in all cases and that the discomfort and continual annoyance of the prothetic may become unbearable. As the result of improvements in technique which have developed in the past few years in this domain, such cases are less frequently seen; but they have not disappeared entirely, as the following case will show:

A young man was admitted to the Augusta Hospital with the anterior portion of the lower jaw shot away. The defect had been restored by a prothetic fashioned by one of our most skillful dentists. The substitute, however, was in no way satisfactory. Saliva flowed from the mouth continually, and chewing was impossible, so that the patient begged in some way to be freed from his discomforts.

For this case Krause recommended a procedure which he had previously carried out eight times, first in the year 1893. Its purpose was to replace the segment removed either in resection in continuity or in unilateral exarticulation. This plastic procedure will elucidate the further course of the operation described on page 316.

After completion of the suture of the mucous membrane for the protection of the wound, the triangular flap was turned down again, but not sewed in (Fig. 336, Plate 61). Then the oblique incision already made for the plastic toward the middle line was lengthened upward to the jaw, and by retracting the upper anterior edge of the wound with sharp hooks, the bone was exposed as far as the

middle line of the chin. At this place under the skin of the chin the periosteum was loosened up a bit and a channel about one cm. deep and one cm. wide was chiseled through the lower half of the bone at about the mental tuberosity (Fig. 336, Plate 61). An incision was then made joining the upper ends of the anterior and posterior oblique incisions, cutting through all the soft parts, until a strip of bone, several millimeters wide, lay exposed.

With the object of cutting out a strip of bone one cm. wide from the lower edge of the jaw, avoiding its inner and outer periosteal covering, a Braatz guide was pushed from behind forward along the inner surface of the jaw through the soft parts of the floor of the mouth, without disturbing the periosteum. This was drawn back with the Gigli saw attached, and the lower jaw was sawn through horizontally from within outward (Fig. 337, Plate 61). As the saw began to tear, the remnant of the bone was cut through with a thin chisel. The piece of bone which was sawed out, and which remained attached to the soft parts, had a length of 6 cm. (Fig. 338, Plate 61).

In order to prevent tearing up of the periosteum during the further course of the operation, the musculature of the floor of the mouth, which was attached to the strip of bone on its inner side, was united to the subcutaneous tissue by means of several interrupted catgut sutures; in this way the sawn surface was practically entirely covered (Fig. 338, Plate 61), but in this suture care was taken to avoid the periosteum both without and within. Through incisions in the musculature of the floor of the mouth, a wedge, becoming broader at the base, was formed, which together with the skin made a wide and freely movable nutritional base for the strip of bone. But before transplanting the thus mobilized osteoplastic flap, two holes were drilled, one at the end of the remaining portion of the lower jaw and the other at the anterior end of the piece which had been sawed out of the jaw. Through this a silver wire was drawn (Fig. 339, Plate 61), and the plastic flap was displaced laterally into the defect under the triangular skin flap, which was now again turned back. The bony strip was now made fast to the remnant of the jaw by twisting up the wire.

The free posterior end of the transplanted bone was placed in the muscle pocket between the internal pterygoid and masseter, and with the aid of two interrupted catgut sutures which penetrated the muscle and the soft parts attached to the bone, it was elevated

slightly. All the remaining small areas of exposed surface on the bony transplant were now covered by sewing the adjacent tissue over them, partly the muscle bundles of the masseter and partly the musculature of the floor of the mouth. In the same way the raw surface of the remaining portion of the jaw, and particularly the region of the silver wire suture, was covered with tissue (Fig. 340, Plate 61), and then the skin of the chin was united over it (Fig. 341, Plate 61).

In sewing the skin edges, care had to be taken to avoid all tension on the bony transplant. For this reason only the posterior edge of the transplanted flap was sewed up, leaving a drainage track. In order to avoid pull, the anterior edge was left entirely open. At this place, also, a small area of the transplanted bone had to remain uncovered. The triangular skin flap could not in this case be made use of, and was cut off transversely; and the upper transverse skin margin was united to the cheek. The portion of the wound which remained open was covered with gauze, and in the lower angle of both wounds a small drainage-tube was fixed.

The course to the fifteenth day was entirely without rise in temperature; on the fifth day, there being no secretion, the drains were removed. The wound was healed along the line of suture. The small uncovered place showed healthy granulations. On the sixteenth day pneumonia made its appearance, ushered in by chills and fever, and resulted fatally for the sixty-eight-year-old patient on the sixth day. Examination of the wound showed a satisfactory closure of the oral cavity, union of the transplanted strip of bone with the segment of the jaw which was left intact, and a firm disposition of its posterior end in the muscle pocket so that the chin was not displaced.

This case, like all other operative cases, involved the resection of 5½ to 8 cm. of bone. Exarticulated portions of the jaw, as well as portions resected in continuity, can be replaced by this method. Even if a very large piece of the jaw has to be removed, it can be satisfactorily replaced by a section of bone from the other side by means of a plastic flap. But in such cases it is necessary, even while extirpating the diseased bone, to make the incisions with regard to the later plastic procedure. As the oral mucous membrane must always be opened in resection, it must be closed again immediately at the end of the operation by direct suture, if possible, otherwise

by a suitable plastic. This should always be done at the first sitting, because after closing off the oral cavity the operation can be interrupted, if necessary for any reason, and completed at a later time. In all the cases operated on up to this time direct suture, or mobilization and sliding of the mucous membrane, sufficed to cover the defect of the mucous membrane without ever having to make use of a skin flap.

If the operation is to be divided into two stages, after closing the oral cavity an ivory pencil, somewhat longer than the extirpated bone, is introduced into the defect and jammed into the inferior dental canal in front and behind. This immediately stops hemorrhage from the inferior dental artery and holds the ends of the jaw in their proper relation. Then the wound is packed, and the skin sewed over with a few stitches so that the wound edges do not retract. Depending on the condition of the bone and the cleanliness of the wound, we have waited four or six days, and once even seventeen days, before completing the operation.

In cutting out the strip of bone for transplantation, a chisel or an electric saw may be used, but the Gigli saw is the most practical. Naturally the oral mucous membrane must be injured just as little as the periosteum. With the help of the probe and a silk thread, the Gigli saw may be passed around behind the jaw, and in sawing it will divide the soft parts as well as bone horizontally; this does no harm to the soft parts. In front a narrow strip of periosteum is always preserved. After sawing out the strip of bone it is necessary to cover the sawn surfaces in the manner directed, in order that no saliva or mucus penetrate to the raw surface and give rise to necrosis.

The mobilization of the plastic flap is carried out through the anterior of the two oblique incisions, which reaches to the level of the hyoid or the *pomum Adami*. This flap comprises all the soft parts, so that the nutrition of the strip of bone shall not be endangered. With the head bent forward the bony transplant may be placed in the defect and fixed by silver wire. In order not to disturb the nutrition of the skin flap, occasionally the horizontal skin incision alone is sutured. The remaining defect may be decreased in size by stitches which are so placed as to cause no pull or distortion of the displaced flap; sometimes it may be closed by making use of the triangular flap.

In the patients first operated upon, using a different incision from

that just described, the transplanted segment necrosed in about one-third of the cases. Two patients healed without necrosis and four others had small sequestra. The ages of the patients varied from fifty-two to sixty-nine years. Ability to open the mouth was good after healing, as well as chewing, although naturally the bite was not strong; the chin is in the middle line. The subject of this photograph (Fig. 342), who was operated on at sixty-eight years, is shown again two years later in Fig. 343, which shows the scar

FIG. 342

Plastic on the lower jaw, after F. Krause; photograph four weeks after operation.

formation. Figs. 344, 345 and 346 are X-ray photographs taken at varying intervals after the operation.

OTHER PLASTIC METHODS

Among other attempts to replace a defect in the lower jaw by transplantation of bone, mention should be made of Wölfer * and Ruediger.† They employed a strip of bone sawed from the clavicle, in connection with a skin flap from the neck. In Wölfer's case the section of bone became necrotic. Bardenheuer‡ employed a flap of skin, periosteum, and bone from the forehead. As he was not satisfied with the results, he devised another method which Wildt re-

* Verhandlungen der Deutsch. Gesells. für Chir., 1892, Part 1, p. 69.
† Zentralblatt für Chir., 1903, No. 45.
‡ Verhandlungen der Deutsch. Gesells. für Chir., 1892, Part 2, p. 123.

ported.* After resection of a segment about 3½ cm. long from the posterior portion of the jaw, a quadrilateral piece of bone of corresponding length, covered with periosteum, was sawed out of the lower edge of the portion of the jaw which was just in front of the defect, its connection with the musculature (platysma myoides and mylohyoid muscles) being maintained. "This piece of bone, together with the attached muscles, first somewhat mobilized, was shoved backward and slightly upward, and fixed in place with wire through drill-holes which had been previously made." "Displace-

FIG. 343

Plastic on the lower jaw, after F. Krause; photograph two years after operation.

ment of the bony transplant was possible below the neck flap, without this itself being displaced backward." The bony transplant healed in solidly; after the resulting ectropion of the lip was corrected by excision the result seemed good.

The method described is, according to the author, "not applicable in large defects of the lower jaw, because the removal of a large piece from the lower margin of the remaining portion of the jaw is not practicable on account of the amount of twisting of the skin, muscle, and bone flap which would become necessary in transplantation of so large a piece of bone." But the Krause method above described fulfills just this purpose in that, as has already been

* Zentralblatt für Chir., 1896, No. 50, p. 1177.

shown, a piece from 5½ to 8 cm. may be resected from the continuity of the jaw and be plastically restored. Sykoff * states that Kiakonow, to cover a defect in the lower jaw, employed a skin-muscle-bone flap taken from the lower margin of the jaw; but nothing more exact can be found concerning his technique. He personally had successfully restored the middle portion of the lower jaw by means of a segment about 4 cm. long sawn out from the left

FIG. 344

Middle section of the lower jaw seen from below; X-ray seven months after operation.

half of the jaw. But he stated that in the future he intended to employ for this purpose a piece of rib with its periosteum.

RESECTION OF THE TEMPORO-MANDIBULAR ARTICULATION: DISEASES OF THE ARTICULATION

Complicated injuries which demand exposure of the temporo-mandibular articulation are infrequent, and incision for acute inflammatory disease or abscess formation is only exceptionally indicated. But extensive operations to overcome the *ankylosis* of one or both articulations which results from injuries of the articulation and inflammatory processes in the neighborhood of the joint are not infrequently necessary.

Such ankylosis of the jaw may, according to von Mikuliez, be *arthrogenous* or *myogenous*, depending upon whether there is complete destruction of the joint surfaces—bony or fibrous ankylosis, on the one hand, or scar degeneration of the joint capsule and the muscles of mastication—that is to say, a contracture of the jaw.

* Zentralblatt für Chir., 1900, No. 35, p. 88.

When the joint on one side is put out of commission, it usually results in loss of motion in the other. In the course of time contracture and scar tissue changes develop in this side also, but these never reach so high a degree as in the joint first affected. Double bony ankylosis indicates the occurrence of a similar disease in both joints.

Cases of inflammatory trismus as the result of edematous infiltration of the soft parts of the cheek, such as may arise, for example, after abscess of the jaw, disease of the roots of the teeth, or fracture

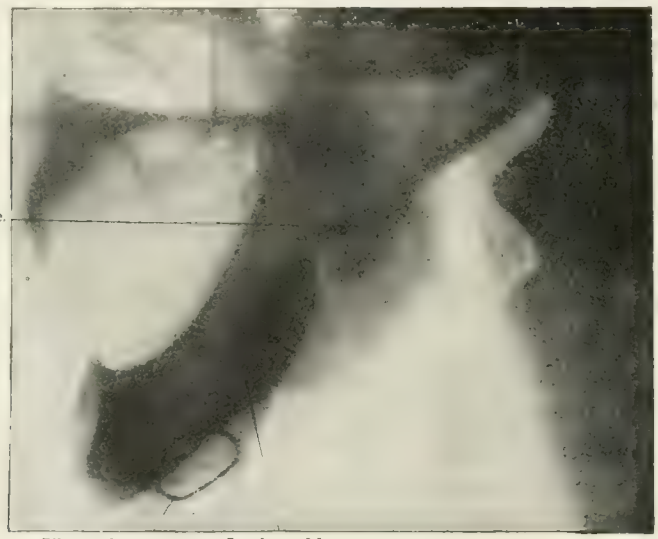


FIG. 345

Lateral X-ray of the left lower jaw, taken seven months after operation.

of the jaw, usually recover without surgical interference. Scar tissue formation in the cheek, for example after noma, burns, or following lupus, may likewise cause fixation of the jaw. In so far as this arises secondarily as the result of scar contracture, it may be corrected by resection of the scar and plastic restoration of the cheek and of the affected corner of the mouth, and particularly of the mucous membrane, without the articulation itself having to be attacked.

As the result of contractures acquired early, particularly in the congenital form, there occurs in addition to the fixation a gradually increasing degeneration of the joint which is not affected, and particularly a distortion of growth in the entire mandible. The bone in many ways maintains the form of the infantile bone, it remains

narrow and low, and neither at the angle nor the chin does it show the characteristic development. As the result of this micrognathia and the disturbed growth of the alveoli, the development of which does not correspond to that of the upper jaw, there results a peculiar deformity of the face which resembles that of a bird or squirrel.

Among the traumatic causes of this deformity, we consider particularly an early injury of the articulation, for example, by means

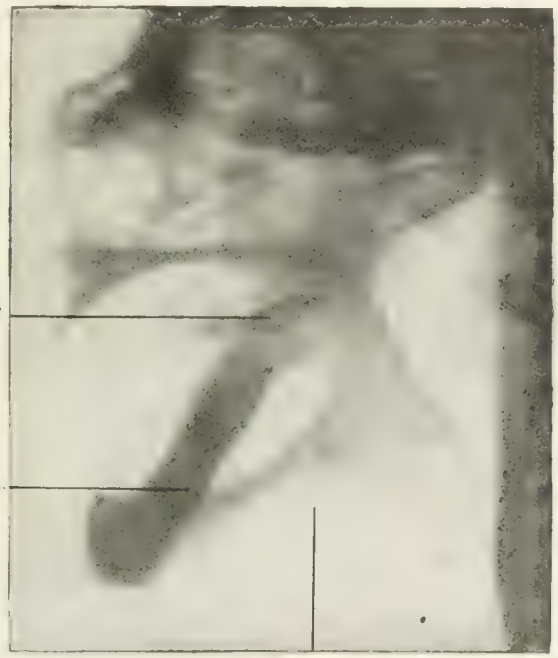


FIG. 346

Lateral X-ray, taken 3¾ years after operation; one wire suture has been discharged.

of forceps at birth, as the result of which the joint is injured, the cartilage loosened or the epiphysis in the region of the condyles destroyed. Also tears of the muscles of mastication may be responsible for early acquired contracture and limitation of development of the jaw-bone, as well as badly healed fractures of the condyles after a fall upon the chin, or tearing of the capsule and meniscus through dislocation of the jaw or too strenuous efforts at reduction. Any inflammation may, if it attacks the joint capsule and the soft parts covering it, cause scar contracture, but if it progresses to the joint surface, particularly with purulent destruction of the joint cartilages, will cause bony ankylosis. Middle ear dis-

ease, abscess of the cheek, parotitis and osteomyelitis in earliest childhood are the most commonly observed causes for a gradually developing contracture.

The symptoms of this affection of the temporo-mandibular articulation are at first, so long as mobility is still present, slight; but gradually a complete loss of motion develops. If we elevate the upper lip in an adult with "squirrel face" of early origin, it can be seen that the molar teeth are solidly approximated, while the incisor teeth of the lower jaw come in contact with those of the upper obliquely or, in some cases against their inner surface. By introducing a spatula between the two sets of teeth, one can discover the loss of mobility of the jaw; under some circumstances a limited degree of passive mobility will be found upon the side which was not primarily affected.

Active opening of the jaw on the part of the patient is only seldom possible, and then only if the ankylosis depends upon contracture of the soft parts and is not bony. Naturally those affected suffer not only from the cosmetically disagreeable deformity, but their nutrition is limited also, since they can take only liquid or semi-solid foods. Such persons pour the food with a spoon into the pouch of the cheek and suck this into the mouth through a natural or artificial opening between the teeth. The speech also is interfered with.

In ankylosis or contractures of the jaw acquired in later years, secondary developmental disturbances do not occur. As causes for ankylosis, in addition to the already mentioned dislocations and fractures through the joint, infected bullet wounds and infectious processes in the vicinity—for example, purulent middle ear disease after scarlet fever or typhoid—and particularly gonorrheal disease, are also to be considered in these cases. Such a condition develops either simultaneously with the gonorrhea or later after the disappearance of the acute symptoms, and, as in gonorrheal affections of other joints, it may remain limited to the one articulation. The inflammatory manifestations are similar to those of acute rheumatic arthritis, although the result of the gonorrheal disease of the articulation of the jaw, in contradistinction to acute rheumatic affections, is practically without exception a bony ankylosis.

Thus, in a thirty-eight-year-old army officer, the left articulation had gradually become completely ankylosed and the original cartilage had been replaced by a bridge of bone firmly uniting the

two joint surfaces, as could be seen by X-ray (Fig. 347), and, after resection, by sawing through the specimen. As a result of the ankylosis he could not enunciate clearly, and he therefore was unable to continue in the service. By extensive resection of the ankylosed joints and the formation of a pseudarthrosis, the jaw was restored to complete mobility. On examination three years later two fingers,

FIG. 347

Bony ankylosis in temporo-maxillary articulation, following gonorrhea.

side by side, could be introduced vertically between the teeth with ease.

OPERATIVE TREATMENT OF ANKYLOSIS OF THE JAW

In operative treatment of all forms of ankylosis, it is important to determine which of the two articulations is affected with the true ankylosis and which is involved secondarily. On the side of the synostosis mobility can be restored only by resection, while slight

changes in the other joint, particularly if some movement is still allowed, may be overcome by mechanical stretching. Assistance in ascertaining which joint is primarily involved may, as a rule, be gained from the history, and from an examination of the ears and of scars or fistulæ in the neighborhood. However, the determination may offer difficulties; even a comparison of the X-rays of the two sides may fail. Testing for passive mobility of one side of the jaw by means of a metal lever is unsafe, because the atrophic jaw on the ankylosed side may at times, as a result of the elasticity of the bone, allow a play of several millimeters. In many cases to be sure a determination of bony ankylosis in advance of operation is without significance, because to obtain complete mobility both articulations must usually be exposed and resected.

If attempts at extension by means of mechanical contrivances or wedges forced between the teeth fail, a pseudarthrosis must be created. Formerly the ascending ramus of the jaw was sawn through horizontally; the results, however, were usually unsatisfactory, as bony union was likely to take place between the ends of the fragments. Even bilateral division of the jaw demonstrated itself as unsatisfactory, since even without bony union, motions of mastication could not be carried out, for the line of division lay in front of the insertion of the muscles of mastication.

Better results were obtained with resection of the condyles after the method of Franz König.* But this method did not always succeed in spite of extensive resection of bone, particularly if scar tissue bands or even bony bridges were present between the articular process and the zygoma, or the soft parts were transformed into dense scar tissue. Von Bergmann recommended in such cases extending the resection to include the coronoid process, particularly if the articular process was entirely undeveloped and misshapen. But in spite of wide resection Borchardt and König observed an ankylosis redevelop six to eight years later in a case of "bird face."

A permanently mobile joint can only be obtained by the method recommended by von Helferich,† an artificial interposition of soft parts between the ends of the bone. Unlike the method of König, only a narrow portion of bone with its periosteum is resected, and a pediculated flap from the temporal muscle is turned into the gap.

By the interposition of muscle, as a rule, a pseudarthrosis and a

* Zeits. f. Chir., Vol. 10, p. 1878.
† Archiv. f. klin. Chir., Vol. 48, p. 864.

Resection of the temporo-maxillary articulation in »Squirrel-face«.

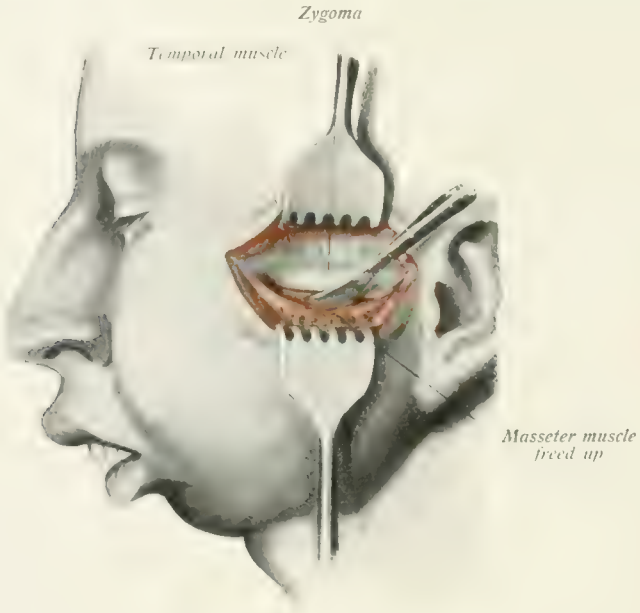


Fig. 348. Incision along the lower margin of the zygoma.

Fig. 349. The incision is extended downwards from the anterior end, and the ramus of the jaw is chiseled across.

Fig. 350. The tendon of the temporal muscle is divided.

Fig. 351. Completion of the resection.

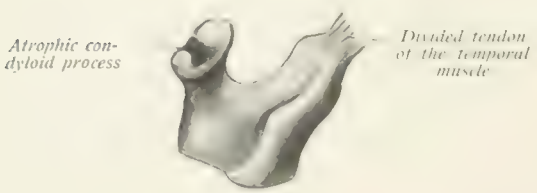


Fig. 352. The resected portion of the jaw seen from within.

Fig. 353. The divided masseter muscle is sewed over cut end of the ramus of the jaw.

permanent separation of the ascending ramus from the base of the skull is obtained. As a disadvantage of this method must be mentioned a slight displacement and shortening of the affected half of the jaw, while after extensive resection an ever-increasing deformity arises as the result of the unavoidable scar contraction. The following operation was carried out on a patient with "bird face" according to the principles of Helferich, with the modification that instead of taking the flap from the temporal muscle, a portion of the masseter was fastened between the bony stumps.

RESECTION OF THE ARTICULATION OF THE JAW FOR EARLY ACQUIRED ANKYLOSIS

A twenty-one-year-old seamstress had a marked deformity of the face. The growth of the lower jaw had been retarded to such an extent that the lower incisor teeth stood a centimeter behind the upper. The upper jaw, moreover, as is apt to happen in ankylosis of early origin, was flattened from right to left. Attempts to open the mouth did not succeed in the least, the jaws could not be pried apart even with the aid of a lever. As cause of the disease, the mother stated that the patient suffered when she was two years old with inflamed glands of the neck, which were opened through the mouth. Following this operation, opening the mouth became increasingly difficult. At the age of ten years the patient could still insert her thumb between the upper and lower teeth, at twelve years only the little finger, and since the fifteenth year the jaw had been absolutely fixed. X-rays showed both joints ankylosed.

It was decided to resect both articulations, and create a false joint by the interposition of a flap of muscle. The incision was made on the left side at the lower margin of the zygoma, dividing the skin of the cheek, the superficial temporal fascia, and the origin of the atrophic masseter muscle, down to the jaw (Fig. 348, Plate 62). With the raspatory, the soft parts were cleaned away from the ascending ramus and shoved downward so that the upper section of the bone lay entirely bare. Nevertheless on account of the strong tension of the soft parts, the transverse incision did not suffice. To gain more room, an incision was made running vertically downward from the anterior end of the wound, allowing the articular process to be exposed. After the lower margin of the wound was drawn sharply downward with a retrac-

tor and a bent elevator was shoved under the ramus on both sides, the ramus was chiseled through transversely (Fig. 349, Plate 62). Whereupon it became evident that the ankylosis on this side was not complete, for after division the proximal portion could be slightly moved.

In order to mobilize it further without endangering the internal maxillary artery, which lies behind the joint capsule, the tight scar bands were stretched by using the elevator as a lever against the cut end of the bone. After the semilunar notch was cleaned up somewhat with knife and scissors, the proximal fragment could be pried outward and the coronoid process and the tendon of the temporal muscle pulled out until it came into full view (Fig. 350, Plate 62). After further incision through the dense scar tissue attached to the zygoma the atrophic and badly deformed head of the bone could, with some difficulty, be dislocated outward. It was now seized with bone forceps (Fig. 351, Plate 62), and the coronoid process freed on its inner surface by twisting it out, and at the same time the tendon of the temporal muscle was divided transversely with a knife. Portions of it remained attached to the coronoid process (Fig. 352, Plate 62).

In spite of the size of the resected segment ($4\frac{1}{2}$ cm. high and $3\frac{1}{2}$ cm. wide above, and 2 cm. wide below), the teeth could not be separated. The obstacle was evidently in the ankylotic joint of the other side. Thereupon the wound was packed with gauze, and the interposition of the masseter muscle, which was divided at the beginning of the operation, was postponed until the resection of the other articulation had been completed. When this second operation had progressed to this same point and the wound of the bone had been packed until there was no further hemorrhage, the interposition of the masseter muscle on the left side, which had already been divided and freed up from the skin, was undertaken. Its completely movable upper segment was turned in over the cut surface of the ascending ramus and made fast to the external pterygoid muscle by two catgut sutures (Fig. 353, Plate 62). In this way the wound surface was covered with a well-nourished flap of muscle which was sufficiently thick in spite of its atrophy, and which thus separated the jaw and base of the skull from each other. A small drainage-tube was left in for three days between masseter and base of skull; otherwise the wound was sewed up tight.

On the right side the same technique was carried out as on the

Resection of the temporo-maxillary articulation in bony anchylosis.

Fig. 354. Incision along the margin of the zygoma, and separation of the masseter muscle.

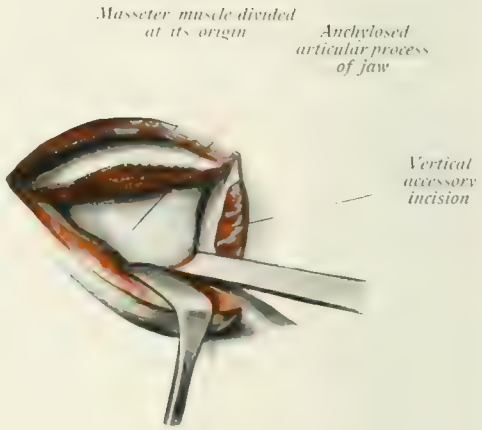


Fig. 355. The joint is resected with a chisel.

Fig. 356. The resection is completed, and the remnants of bone under the zygoma are removed.

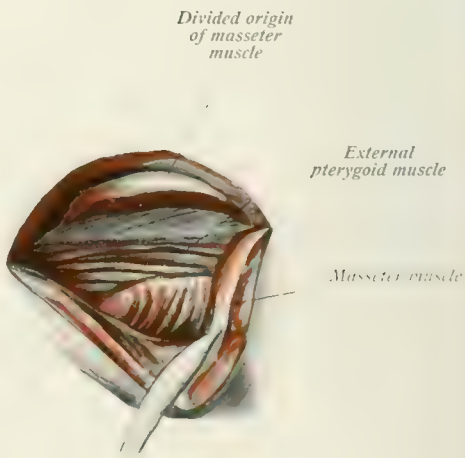


Fig. 357. The masseter is freed up, for interposition between the chiseled surfaces.

left. For this joint, also, the single transverse incision below the zygoma did not suffice (Fig. 354, Plate 63), and a vertical incision 3 cm. long had to be carried down from the anterior end of the wound (Fig. 355, Plate 63). While on the left side the immobility of the jaw was found to be due to sclerotic scar tissue, on the right there was a complete bony ankylosis which allowed no trace of passive motion. As a result division of the contracted parts had to be given up and the entire joint chiseled out (Fig. 356, Plate 63). Near the joint and farther below the original capsule, the muscles had become converted into a sclerotic and partly ossified tissue. Moreover, on this side the coronoid process had completely disappeared, and in place of the joint there was only a rim of bone projecting below the zygoma. Nothing could be seen of the temporal muscle.

After completion of the resection, the remnants of bone at the original joint surface were chiseled away from the base of the skull (Fig. 356, Plate 63), until in the depths the external pterygoid and the skull were exposed. Finally, just as on the other side, the masseter was dissected up for a certain distance (Fig. 357, Plate 63), the freed portion was turned in over the cut surface of the ascending ramus, and held in place by three sutures in the internal periosteum and the external pterygoid muscle. The wound was closed except for an opening for a fine drainage-tube.

The wounds healed without incident and the patient was discharged four weeks later. The mouth just after operation could be opened so wide that the upper and lower teeth were separated 2 cm. At first the patient had no strength in chewing, and the lateral motions of the jaw were also lacking, but improvement in chewing resulted from training; moreover, through forcing wooden wedges between the teeth, there was gradually induced a stretching of the deformed and inelastic muscles of mastication.

The improvement was carried to a considerable degree, as is evidenced by a letter from the patient written four years after operation. According to this she had been chewing again for several years and had been able to eat solid food; she declared that she was greatly pleased with her improved condition.

Just as in early acquired ankylosis, resection of the jaw may be indicated in later acquired deformities of the jaw; for instance, in joint changes caused by exostosis of the coronoid process or through

arthritis deformans. However, resection is only necessary when as the result of the lack of normal relations between the articular surfaces chewing or closing of the mouth becomes impossible. The technique does not differ from that described for the correction of ankylosis of the jaw.

CHAPTER 14—SURGICAL AFFECTIONS OF THE ORAL CAVITY

DEFORMITIES AND INJURIES WITHIN THE ORAL CAVITY

The subject of congenital clefts in the jaw and palate and their surgical treatment has already been taken up (p. 134). Other deformities for the repair of which surgery offers assistance are rather infrequent in the oral cavity. They are limited to bands or weblike adhesions between the various structures in the mouth; for instance, between tongue and floor of mouth, palate, pharynx, or cheek.

TONGUE-TIE

In infants there is frequently observed an attachment of the tip of the tongue to the floor of the mouth, or even to the mucous membrane of the jaw, by a frenum which extends too far forward and which is too short. The result of this is difficulty in sucking, as the tongue cannot be extended forward and the sides curved up cylinder fashion. This fault of development may readily be corrected by dividing with blunt-pointed scissors on the under side of the tongue the little band of tissue which extends too far forward.

Injury of the ducts of the salivary glands may be avoided by lifting the tip of the tongue high upward while the mucous membrane of the floor of the mouth is pressed down with the index finger or with the myrtle leaf depressor at the end of an ordinary director. The scissors in cutting should always be in contact with the inferior surface of the tongue.

Ordinarily a small nick at the anterior end of the tight band is enough to mobilize the tip of the tongue. The connective tissue attachments may be loosened farther backward by blunt dissection with the finger nail. To control hemorrhage, pressure with a sponge for a few minutes ordinarily suffices. If by chance an artery is injured, it is seized with a snap and tied off in order to avoid further loss of blood, which might be important in infants. The tongue once loosened, as the result of its mobility it is not likely to become adherent again.

WOUNDS AND FOREIGN BODIES IN THE SOFT PARTS OF THE ORAL CAVITY

Concerning injuries and wounds in the oral cavity, the same principles hold as for injuries of the jaw (see p. 269). Wounds of the palate, mucous membrane of the cheek and tongue, show a special disposition to healing rapidly without infection, even if their edges are macerated. On account of the favorable conditions for healing, tabs of the tongue such as occur after a bite or tear or gun-shot wounds, should never be removed even if they hang very loosely; it is much better to attach them by a few stitches to their proper place. The same holds good in injuries and tears of the mucous membrane of the palate. The suture may be followed by considerable swelling, but this disappears rapidly and does not in itself signify infection.

Bullets, bits of clothing, fragments of bone and other foreign bodies in the tongue are likely, after a certain length of time, to provoke abscess formation and must be removed by an incision into the tongue of sufficient size. Fish bones, which on swallowing are likely to remain sticking in the tonsils or in the pyriform sinus, should be removed as early as possible in order to anticipate irritation and danger of inflammation. In working on the base of the tongue, the reflexes of retching and coughing should be overcome by painting the mucous membrane of the pharynx with 20 per cent. cocain. Then with the tongue depressor the tongue may be pulled far forward and depressed, in order to allow all the pockets of mucous membrane to be examined for the foreign body. Fish bones should be seized with anatomical or, better still, with epilation forceps and pulled out.

As the result of insect bites, an injury which may happen in eating fruit, in sleeping with the mouth open, or outdoors in talking or driving, the tongue may swell up to the point where danger of suffocation arises. As the result of cuts of the mucous membrane with blades of grass, or after the reprehensible moistening of postage stamps with the tongue, similar threatening conditions may be observed. If the edema does not go down after cocainization or multiple scarification of the surface of the tongue, tracheotomy may even become necessary to prevent the injured person from suffocating.

LIGATION OF THE LINGUAL ARTERY

Bleeding from wounds of the tongue is likely to be severe, but in fresh wounds it is ordinarily controlled by suture. More dangerous is the secondary hemorrhage from infected friable tissue in which all ligatures pull out. In that case tying of the lingual artery of one or both sides is to be considered.

The technique is as follows: With the head bent sharply backward,

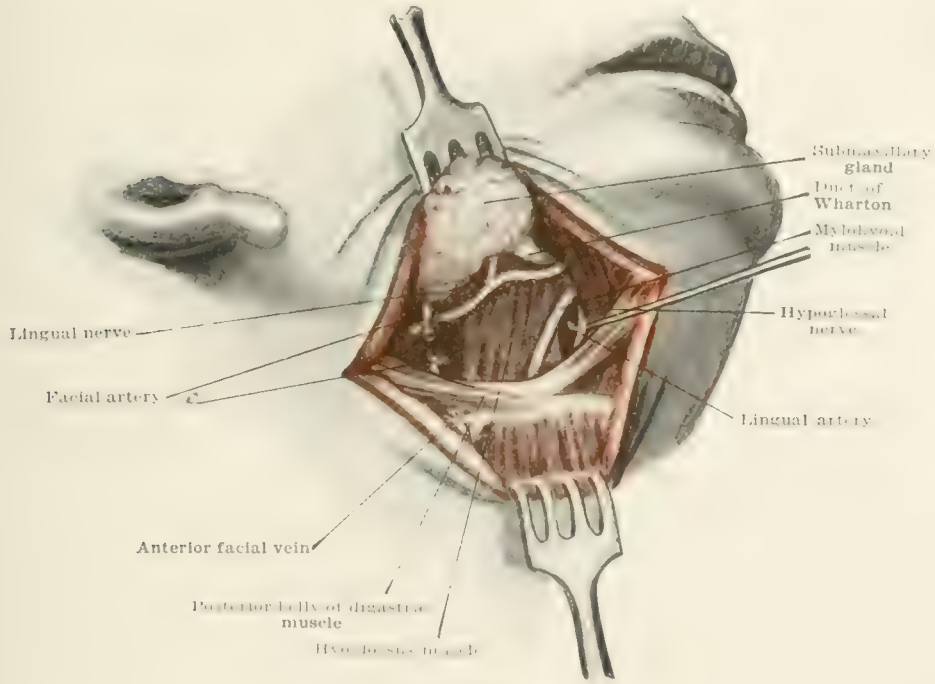


FIG. 358

Ligation of the lingual artery.

a crescentic incision is made a finger's breadth below the margin of the jaw (Fig. 358). Together with the skin the platysma myoides and the underlying fascia are divided, and the submaxillary gland exposed. After enlarging the incision in the fascia forward and backward, the submaxillary gland may be shelled out from its muscle bed by blunt dissection, pulled out from under the jaw and turned up over its lower edge. This puts on the stretch the duct which runs upward and forward into the floor of the mouth. If the incision is not too small, there will come into view the anterior facial vein, or even the common facial vein, upon the common sheath of

the stylohyoid muscle and the posterior belly of the digastric. The anterior edge of these two muscles form on one side with the posterior margin of the mylohyoid muscle, which is clearly seen on bending the head toward the other shoulder, and on the other with the edge of a turned-up submaxillary gland, a triangular field which is crossed obliquely by the hypoglossal nerve and the lingual vein. If the nerve and vein are turned upward with a blunt hook and the vertical fibers of the underlying hypoglossal muscle are separated in the direction with which they run, the lingual artery is exposed. It is drawn up on a hook, double tied and divided.

ABSCESS FORMATION WITHIN THE ORAL CAVITY

In spite of the antiseptic power of the oral secretions to which may be referred the practically constant healing of fresh wounds of the mucous membrane without reaction, bacterial infections in the form of extensive infiltration, limited abscesses, and even of wide-spreading cellulitis, are no rarity. As the source for such condition, we in many cases consider the permanent foci of bacteria, for instance the crypts of the tonsils, and the alveoli of carious teeth. Infection, however, may also arise from foreign bodies which have carried in with them the source of inflammation.

So long as a purely serous or purulent infiltration is limited to a small section of the gum, palate, tongue, or floor of the mouth, the danger from such infection is small. The condition becomes more serious as soon as edema or pus formation extends into the loose submucous tissue, spread from there to the pharynx, the wall of the larynx or into the peritracheal connective tissue, or in certain circumstances even into the mediastinum. But such limited pus collections in the oral cavity lead often to serious symptoms which are accompanied by pain on swallowing and talking, and high fever. Moreover, when situated on the soft palate, in the peritonsillar tissue or at the base of the tongue, they may with an increasing collateral edema of the mucous membrane cause considerable obstruction to respiration. In such cases tracheotomy may be necessary in localized abscess exactly the same as in rapidly extending phlegmon.

ALVEOLAR ABSCESS

The most harmless form of all circumscribed collections of pus within the oral cavity is the alveolar abscess. In many cases the port of entry for the pus organism is outside the tooth at the border

Incision of an alveolar abscess.

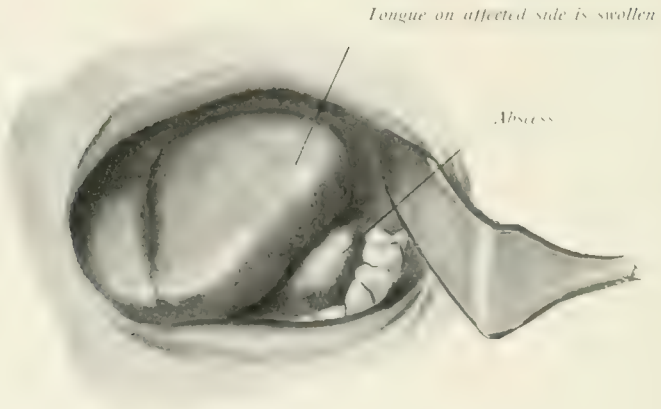


Fig 359. Abscess on the lingual side of the alveolar process.

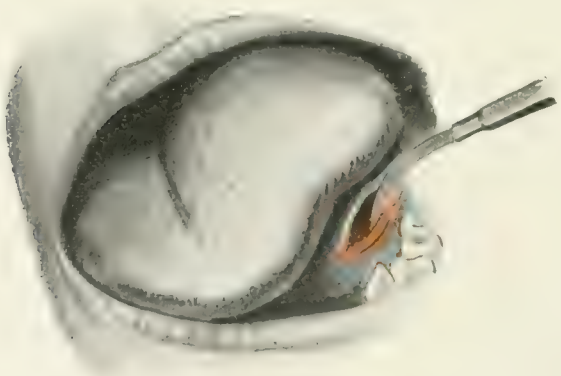


Fig. 360. Incision with a curved bistury.

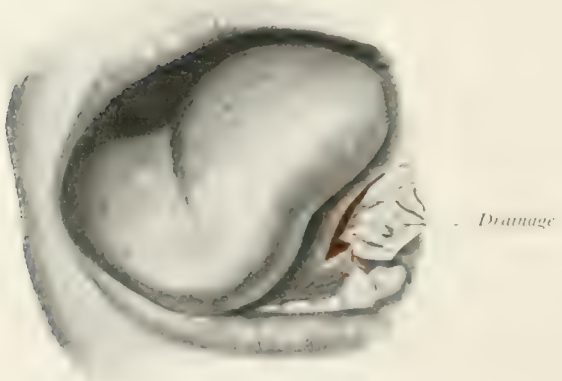


Fig. 361. Packing the abscess cavity.

of the gum. There then develops a local abscess limited to the immediate locality (Fig. 359, Plate 64), which after wide incision extending to the bone (Fig. 360, Plate 64), and after being drained for a few days (Fig. 361, Plate 64), heals up rapidly. In other cases the cause may be sought in a carious or dead tooth, of which the alveolar periosteum is infiltrated with pus.

This alveolar periostitis, which precedes the formation of the abscess itself, causes the patient a thumping pain, worse at night and on touching the tooth with cold foods and liquids, and on chewing suggests the feeling that the tooth is too long. Sometimes serious symptoms of general septic infection follow this ordinarily trivial affection. The usual manifestations are swelling of the mucous membrane of the jaw, occasionally extensive edema of the cheek, and sometimes also inflammatory trismus. In spite of the swelling, the tooth which is responsible for the difficulty is practically always to be recognized by the severe pain which is aroused by pressure with the finger against the affected alveolus, and also by the sensitiveness on tapping the crown of the tooth with a metal instrument or by squirting cold water against it. This determination is of importance, if several teeth are affected with caries, or no one of them appears diseased externally.

For the abscess which arises from the pulp of the tooth, incision of the abscess alone does not suffice to cure, but in addition the tooth must be treated. Roots or stumps should be extracted; in spite of an erroneous popular opinion, this should be done even in the presence of inflammatory ankylosis or extensive edema. If one desires to preserve the tooth, the dentist should make an examination, and if it seems advisable, sterilize and then fill the carious cavity.

DENTAL FISTULÆ

In abscesses which result from inflammation of the periosteum of the root, pus seeks a way through the mucous membrane of the jaw and appears under this on the labial, or less frequently on the lingual surface. If this is not incised, it breaks through the mucous membrane and causes a fistula. Less frequently the spontaneous opening occurs on the skin of the face, with the formation of a fistula of the cheek, jaw, or chin. Sometimes pus from the roots of the molars of the upper jaw breaks into the antrum of Highmore, causing an empyema of the antrum. Even though all acute manifestations disappear with the spontaneous opening, nevertheless in

many cases a long fistulous track results which goes down to the affected root. Through such an external fistula there exudes once in a while with the secretion a dead remnant of the root or a necrotic bit of bone, following which, as a rule, healing shortly sets in. But so long as the source of pus formation is not completely removed, the fistula reopens.

If in such a chronic external fistula the mucous membrane has completely closed over the affected alveolus, the determination of the real source of inflammation offers difficulties. It can usually be found by passing a director into the fistula and incising along it down to bone. But simply excising the fistula in the soft parts and curetting does not induce healing unless the jaw has been chiseled through into the alveolus and all the small sequestra and the remains of the root have been removed. This operation may be carried out under local anesthesia, and will cure in a short time an external fistula which may have been running for months.

To correct the disfigurement from the funnel-shaped scar following such a fistula, which goes down to bone, an oval incision must be made around it and the soft parts freed from the bone and the skin sewed up in a straight line. Neuber has transplanted little flaps of fat under the freed-up skin to correct disfiguring sunken scars following fistulæ in the neighborhood of the margin of the lid, to create a better cosmetic result; this technique may be employed also in the cases just cited.

The question as to what disease lies behind an external fistula in the face may be decided in many cases by the location of the fistula. Those arising from a diseased root are usually found in its immediate vicinity, particularly on the lower jaw, where they are much more frequently observed than on the upper jaw. Confusion with fistulæ of other origin is particularly easy on the upper jaw; nevertheless, osteomyelitic fistulæ arise from diseased lower incisor or canine teeth. Actinomycotic fistula, in contradistinction to the dental fistulæ, are usually multiple.

RETROMAXILLARY PHLEGMON AND LUDWIG'S ANGINA

In spite of the fact that in alveolar abscess the accompanying inflammatory edema, as a rule, spreads over large sections of the face, the purulent softening in most cases remains limited to circumscribed portions of the jaw in the neighborhood of the affected tooth. Only exceptionally is there extension of the pus formation

and a progressing cellulitis. On the upper jaw, this is sometimes seen following a difficult eruption of a wisdom tooth. The infiltration may spread along the maxillary tuberosity into the pterygopalatine fossa, and from here extend either forward as a deep temporal cellulitis, or as an orbital phlegmon to the meninges. For exposure and drainage of the infiltrated tissue, resection of the lateral wall of the orbit or of a zygomatic process may become necessary.

On the lower jaw cellulitis may also arise from carious molar teeth, proceed in the interstices between the floor of the mouth and the hyoid muscles, and spread downward into the loose tissues between the neck muscles, even so far as the mediastinum. From the floor of the mouth it early involves the region of the submaxillary gland, and is restrained here by the thick fascia of the neck which covers this gland externally. As a result the region of the submaxillary triangle is in such case the source of a great deal of pain and tenderness on pressure, and is likewise usually infiltrated and swollen.

This form of phlegmon of the floor of the mouth is known and respected under the name of Ludwig's angina. It represents one of the most dangerous of local infections, since in spite of early incision it ends fatally in a large number of cases. Usually, on account of the rapidity with which the infiltration extends, there is no abscess formation, but the patient goes to pieces rapidly, either from edema of the glottis or from the severe intoxication.

The treatment consists first of all in wide opening of the submaxillary pouch from without; the incision corresponds to that for resection of the lower jaw (p. 313). The tongue and the lingual mucous membrane of the jaw must also be incised widely from within the mouth, in order to procure an outlet for the inflammatory edema, and for the usually limited purulent secretion. Difficulty in breathing points to a beginning edema of the glottis, and to prevent suffocation a tracheotomy should be performed early.

TONSILLAR ABSCESS

Practically all the swellings of one side of the soft palate which come to surgical treatment are mistakenly considered tonsillar abscesses. The abscess, as a rule, does not take place in the tonsil itself, but in the loose tissue which connects it with the anterior and posterior pillars of the fauces. The cause for these peritonsillar abscesses is usually to be sought in a follicular tonsillitis, but they do not cause destruction of the tonsil itself. Much more frequently

the pus organisms following a catarrhal inflammation of the mucous membrane proceed from the crypts of the tonsil into the peritonsillar tissue and over beneath the palatine arch. A purulent softening then occurs at the upper external and posterior surface of the tonsil. The very infrequent abscess of the tonsil itself develops without attracting attention; it grows very slowly with the diagnosis of tonsillitis, and finally breaks through the mucous membrane at some point on the surface.

Peritonsillar abscess formation, on the other hand, begins at once with septic manifestations, which arise suddenly with chills and fever, following an ordinary sore throat. Then there appears an increasing swelling of the soft palate and displacement of the uvula to the opposite side and backward, marked pain on swallowing, swelling of the cervical glands and inflammatory trismus. Not infrequently the isthmus of the fauces is completely shut off. In the worst cases interference with respiration may develop as the swelling of the root of the tongue and of the glottis gradually increases.

Diagnosis is clear in most cases, even before palpation and examination of the throat, by the history and by the characteristic expression: the slightly opened mouth, the head held rigidly and bent slightly backward, and the pure nasal and somewhat impeded speech. If the palate is much swollen, the tongue is pushed forward and projects between the teeth. The saliva for the most part runs into the mouth, because the patient anxiously avoids swallowing. On examination there can be felt externally in the neck tender and enlarged lymph nodes; within the mouth there can be seen at the isthmus a spherical protuberance on the affected side of the soft palate. The position of the uvula and the extent of the infiltration can only be determined after the tongue has been pushed down with a depressor. If the inflammatory trismus makes it impossible to open the mouth wide enough, this may be accomplished with a gag or under an anesthetic. Palpation of the palate cannot be effectively accomplished, as a rule, without forcible opening of the mouth; but it is necessary in order to locate the fluctuating point in the extensive area of swelling.

If the infiltration of the peritonsillar tissue is left to itself, the corresponding half of the palate becomes rapidly affected. The uvula is also usually involved, and as the anterior pillar is more frequently affected than the posterior, it is displaced backward as the swelling increases. Finally the isthmus may be completely blocked

as the result of swelling. In the course of a week or more, at a point corresponding to the upper margin of the tonsil, a discoloration appears in the reddened and tense mucous membrane, and at this place spontaneous opening is likely to occur. But one should never wait for this, for, leaving out of consideration the ever-present danger of acute edema of the glottis, the abscess may burst during sleep or when the patient is unconscious and the larynx be so filled with pus

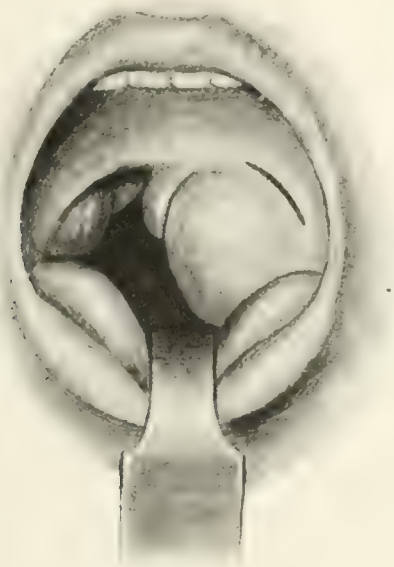


FIG. 362

Left-sided peritonsillar abscess, showing incision.*

The mouth is shown more widely opened than would actually be possible, on account of the infiltration of the soft parts.

that assistance is of no avail; in the more favorable cases aspiration into the lungs may result.

In order to avoid these possibilities and to afford immediate relief to the patient in his distress, wide incision into the tissue can never be made too early, as peritonsillar inflammation leads, as a rule, to abscess formation, and practically always on the upper outer edge of the tonsil, where the two pillars meet and form the supratonsillar fossa (Fig. 362). In order to find this point with assurance, the normal folds being destroyed and the other anatomical landmarks being indistinguishable, one should follow the method of Chiaris, according to which the incision is made at a point half way between

* From Bruck, Diseases of the Nose and Throat, Rebman Company, New York.

the base of the uvula and the last lower molar tooth. It runs parallel to the line of the anterior pillar in a sagittal direction and should be made 2 or 3 cm. deep. To incise farther out or to go any deeper is not without a certain element of danger, for at times a misplaced internal carotid or the ascending pharyngeal artery may be injured.

If the abscess is fully formed or if rupture is threatening, it is necessary only to divide the mucous membrane of the well-cocainized palate with the point of the knife. Then it is easy to open the pus pocket by blunt dissection, introducing closed dissecting scissors or curved forceps into the incision. If the incision is made on the second or third day of the disease, there issues often from the peritonsillar lymph spaces no fluid pus, but only the serum of the infiltrated tissue. But this suffices, after exposing and opening the bed of the tonsil, to put a stop to the spread of the infection, and to determine an opening at this point after the abscess has formed. The incision must go deep enough, at least 2 cm. from the surface. In order to prevent the wound edges from adhering too early, a strip of narrow iodoform tape is introduced into the pocket. Incisions may conveniently be made with a double-edged knife, which is wrapped with sterile gauze except for the tip, in order to avoid injury to the mucous membrane of the mouth on introducing it. Hemorrhage on opening the abscess is not to be feared, if one has taken care beforehand to see that no veins or arteries which are abnormally placed lie in the line of incision, and if in incising and proceeding into the depths with the instrument, one never leaves the sagittal plane.

Usually the patients feel much relieved immediately after the incision: they breathe and swallow and talk much more easily. In a few days the swelling of the palate goes down and only the inflammatory swelling of the tonsil remains. The after-treatment consists in washing the mouth with 2 per cent. hydrogen peroxide, and if the swelling of the neck is severe the use of an ice collar or a Priessnitz dressing. The iodoform drain is removed on the third day and need not be replaced. Only in case the first incision proves too short or too shallow does it become necessary to make a second a few days later.

Recurrences are frequent. In some persons peritonsillar abscesses arise after every attack of tonsillitis, and since the affected tonsil becomes hypertrophied and infiltrated with inflammatory prod-

ucts, the best prophylactic is removal of the tonsils. And since, moreover, a series of other affections may arise in the nose, pharynx or larynx from hypertrophied and chronically inflamed tonsils, and in such case tonsillectomy is likewise indicated, we give here the technique for that procedure also.

TONSILLOTOMY AND TONSILLECTOMY

For the removal of hypertrophied tonsils there is employed an instrument particularly devised for this purpose by Fahnenstock, the tonsillotome, or one of its numerous modifications. It consists of a pointed fork to impale the tonsil and a ring-shaped knife, which is shoved forward from under a protecting ring. On pushing forward the stem, with one motion the tonsil, which lies in the protecting ring, is seized and amputated.

The tonsillotome is made in various sizes for children and adults. The ring should not be too broad, otherwise the tonsil may slide out when the instrument is closed. It is important on introducing the instrument to hold the tongue out of the way with a depressor, so as not to catch the uvula in the ring and clip off a piece. If the tonsillotome is held tight against the lateral wall, the tonsil which is removed cannot fall out, and none of the accompanying dangers are to be feared. The left tonsil is removed with the right hand, and the right with the left.

One disadvantage in this method lies in the fact that the tonsil is not completely removed. Only the part which projects between the pillars can be cut away, and the rest remains intact. For hypertrophied tonsils and the symptoms which arise therefrom, this incomplete removal ordinarily suffices. The operation has recently been modified by Sluder, who uses a tonsillotome of a different type, and pushes the tonsil into it by pressure of a finger behind the angle of the jaw. His procedure brings away more of the tonsil. Plate 15, p. 135, in Volume I, shows how the tonsils may be seized with forceps and cut out with a knife.

If the tonsils are retracted by scar formation and are degenerated cystically or are shrunken into a hard mass of tissue, one must attempt a radical extirpation. This is accomplished best by shelling the tonsil out completely within the peritonsillar tissue, after the mucous membrane lining the supratonsillar fossa and along the anterior pillar has been incised. The tonsil is freed up at the upper pole, and then it is freed downward from its position in the connective

tissue by means of a closed scissors or blunt dissector, or, as recommended by Wagener, with a large semi-blunt curette.

The ordinary technique is to seize the tonsil firmly with tonsil forceps (a right-handed volsellum with a long handle), and incise the mucous membrane in the supra-tonsillar fossa and behind the anterior pillar with a tonsil knife such as that of Leland. The tonsil is freed up somewhat by dissection with the finger, or a special blunt dissector (for example, that of Smithwick) is employed. The loop of a wire snare is then passed over the handle of the forceps, the tonsil is pulled toward the middle line, the loop insinuated around its base and drawn tight. The tonsil will usually be found intact within its capsule. Any tabs of tissue remaining may be trimmed off with a tonsil punch.

In the employment of the tonsillotome there comes, at first, an active parenchymatous bleeding, which after a short time ceases of itself, if the removal has really been carried on in the tonsillar tissue and the anterior pillar or the uvula has not been injured. If the hemorrhage continues, it suffices to exert pressure with a gauze sponge. A spurting artery may be seized with a hemostat and tied off. If this is not successful, the pillars may be sewed together over the wound or they may be united by clamps, such as those of Michel. Injuries of the internal carotid artery need occasion little fear, since this lies about 2 cm. external to the pillar. In order to be safe, one may feel with the index finger before doing a tonsillectomy to see if a pulsating vessel lies just under the surface.

Less to be recommended is the technique of Helferich, who fastens a tampon against the tonsillar wound by means of suture. The needle is introduced from without in the neighborhood of the angle of the jaw, and is carried through the soft parts of the neck and brought out again to the surface. In order not to injure the great vessels, the lateral wall of the trachea is pushed outward with the index finger within the mouth. The ends of the silk are tied externally over a gauze roll or a drainage-tube, in order to disseminate the pressure and to prevent the suture from cutting through rapidly.

The difficulties after tonsillotomy are usually slight. After tonsillectomy, on the other hand, a certain amount of pain may persist for a short while. There is more likely to be oozing of blood from the bed of the tonsil, swallowing is often difficult, and the speech may

be affected for some time, which is a disadvantage to the patient. The patient should be kept in bed for several days, if there has been active bleeding, in order to avoid the danger of secondary hemorrhage. Solid food at first is forbidden, but small pieces of ice or cold milk may be given. Mouth washes do no harm to the wound, but strong gargling is not advisable, on account of the danger of infection and of secondary hemorrhage.

Removal of the tonsils with the tonsillotome may, if done skillfully, be performed without anesthesia. Then the child (for this operation is usually done in children) should be held tightly. A nurse should take the child on her lap between her knees facing her right, lay the left arm about the forehead of the child, bend the head backward and hold it against her shoulder. With her right hand she seizes the arms.

In contradistinction to tonsillotomy, the radical extirpation is quite painful, and must, therefore, be done under ether or under local anesthesia. The mucous membrane is painted with 20 per cent. cocain solution, to 25 cm. of which 10 drops of suprarenin has been added. In addition, at the upper edge of the tonsil in the fold near the anterior pillar, and if possible at the lower pole, there should be injected 2 or 3 c.c. of ½ per cent. novocain-suprarenin solution.

TONGUE ABSCESS AND PHLEGMONOUS GLOSSITIS

Local abscess formation in the tongue commonly results from a foreign body which has penetrated on chewing. The abscess may develop chronically in the course of several weeks, and then forms a nodular indurated mass in the tongue, which can be definitely palpated. It may be readily confused with gumma or tumor, particularly as chronic abscess of the tongue, except for the beginning of its development, is likely to be unaccompanied by the ordinary symptoms of inflammation. Treatment consists in opening and packing the small abscess cavity.

Much more dangerous is the phlegmonous infiltration, which spreads rapidly to the base of the tongue, the soft palate, epiglottis, and the arvepiglottidean folds, and which often requires early tracheotomy on account of the danger of suffocation. As causes are to be considered injuries from infected foreign bodies, and pressure sores from the sharp points of carious teeth. The disease may take its origin from the tonsils, following a phlegmonous sore

throat, and finally, like the Ludwig's angina which progresses under the tongue, from an alveolar periostitis of the jaw.

The chief symptom of this diffuse cellulitis is swelling of the tongue, particularly at its base. As the result of this the mobile anterior half of the tongue, together with the tip which usually escapes involvement, are shoved forward between the teeth; but in the back part of the mouth the soft palate, as well as the uvula, are pushed backward and upward, and the epiglottis is displaced downward against the larynx. All saliva flows out into the mouth, as swallowing is impossible. On account of the mechanical obstruction there is commonly difficulty in breathing. In sitting up, the patient holds his head bent sharply forward on the breast, because in this position the respiration through the naso-pharynx is rendered free. It is impossible in most cases to examine the oral cavity, since the mouth cannot be opened on account of the inflammatory trismus, and touching the tongue with the depressor causes excruciating pain. The temperature as a rule reaches the high levels of a general septic process, but it may in exceptional cases hold to a median grade. Likewise, a marked increase in the rapidity of the pulse is usually noticed. Painful swelling of the cervical and submaxillary lymph nodes is seldom absent, even at the beginning of the disease.

When edema of the glottis threatens, the difficulty in respiration can be relieved only by tracheotomy, but in the large proportion of patients the swelling reaches its acme before this procedure is indicated, and then advances no farther toward the larynx. There then appears a purulent softening of the infiltrated portion of the tongue and of the anterior pillar. In order to limit so far as possible the spread of the edema and to allow exit for the pus which is present, the infiltrated region should be incised early. Complete anesthesia is not necessary for this incision, and it may even be dangerous on account of the possibility of aspiration of pus; however, the preliminary examination, including the palpation of the base of the tongue and of the palate, requires a light anesthesia, for without this assistance the mouth cannot be opened.

If the point of origin of the cellulitis of the tongue is evident, if it lies, for example, on the alveolar process or the soft palate, after introducing the mouth gag, an incision of adequate length is made at that point through mucous membrane and the subjacent musculature. The tongue itself is pushed forward and to the normal side

with the finger or depressor, and is split in a horizontal plane. This is done with a sickle-shaped knife, beginning far back at the base of the tongue, and is carried deep in the musculature of the uniformly thickened tongue substance, from behind forward to near the tip.

Whether pus or only a little turbid foul-smelling fluid emanates from the incision, the tension is at once relieved and the threatening swelling reduced. Even if the temperature and pulse remain high and the swelling of the tongue does not go down, the obstruction to respiration is overcome, together with the anxious disquiet of the patient, who feels much relieved. The mouth gag is allowed to remain in place until the patient recovers from the anesthetic; as soon as he is half awake, danger of aspiration of blood or pus disappears. Usually hemorrhage is slight or is controlled by pressure with gauze for a few moments. Once in a while it is necessary to leave in packing, which is brought out through the mouth.

SIMPLE INTRA-ORAL RESECTION

The majority of operations on the tongue, the mucous membrane of the cheeks, and the palate may be comfortably carried out with the mouth wide open, without the necessity of an accessory incision through the cheek, or of autoplastic methods. The approach to the oral cavity is wide enough and may be increased by depressing the tongue, particularly if the reflex activity of the floor of the mouth and of the lower jaw have been overcome by painting with 10 per cent. cocain solution. If the lips hang down and get in the way, they are drawn upward with a blunt hook or to one side with a cheek retractor. If the mouth is to be kept open for an operation that takes considerable time, the Whitehead gag or a similar instrument should be used. In operating on the floor of the mouth, the tongue depressor attachment which is fastened to the lower portion of the depressor is removed.

Of operations which may be performed through the open mouth, in addition to the opening of abscesses, there may be mentioned the shelling out of benign submucous tumors or cysts, the extraction of sequestra in gummatous processes on the palate or splinters of bone after gunshot wounds, the dissecting out of tuberculous or actinomycotic fistulæ and ulcers, and finally all procedures for which, as in noma, the Paquelin cautery is indicated. In Volume I, p. 136, it has been shown how readily the operation for cleft palate may be performed through the open mouth.

Of the more extensive operations within the oral cavity, which require no accessory incision through the cheek or jaw, is to be mentioned wedge-shaped resection of the anterior segment of the tongue for tuberculosis or gummatous disease, the tongue having been first drawn out by a stout silk thread. In malignant disease this simple procedure is to be considered only if the focus is assuredly limited to the tip of the tongue, and not if the tumor extends laterally to the region of the floor of the mouth or to the base of the tongue. Benign formations such as macroglossia, caused by cavernous lymphangioma on the dorsum of the tongue, as well as pediculated fibromata and less frequently submucous lipomata, may without exception be removed through the open mouth, even if they occur as far back as the base of the tongue.

In resections in the mobile portion of the tongue, out of regard for exact union of the wound edges and later function, it is of advantage to cut out a wedge with a base lying either at the anterior margin of the tongue or on the dorsum. The apex will then be either near the base of the tongue or at the lower surface of the tongue. In either case, with careful suture of the wound edges a new tip may be formed, which will be a good imitation of the natural. The following case will serve as an example.

WEDGE-SHAPED RESECTION OF THE TONGUE

In a sixty-five-year-old patient who was suffering from advanced tuberculosis of the right lung there developed an extensive tuberculous infection of the tongue. On the upper and lower aspects of the tip of the tongue there was seen a deep infiltrating ulcer in the neighborhood of which, particularly on the left side, were numerous aphthæ-like vesicles (Fig. 363, Plate 65). As the patient suffered severely in chewing, and even in taking liquid food, his nutrition rapidly deteriorated. In order to bring about at least improvement in this regard, a wedge-shaped excision of the diseased portion of the tongue was undertaken.

After insertion of a gag (Fig. 364, Plate 65), the tongue was pulled out with the fingers, and two stout silk sutures were passed through it as far back as possible, the ends tied, and the tongue drawn out by pulling on these loops. Close to the loops, and a considerable distance behind the affected portion, a wide wedge was cut out from the anterior section of the tongue (Fig. 365, Plate 65). All loss of blood was spared the patient, on account of his weakened

Wedge excision of the tongue.

Fig. 363. Tuberculosis of the tongue.

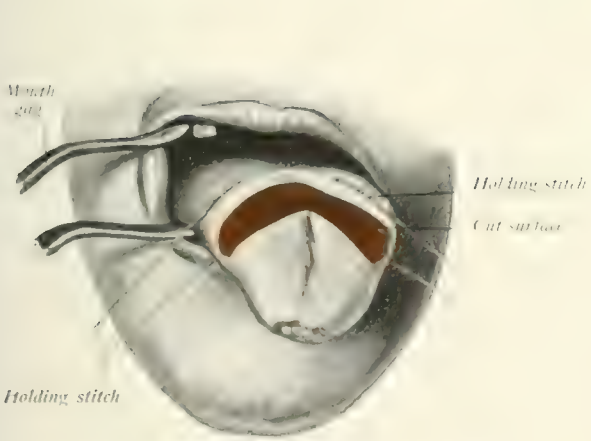


Fig. 364. Resection of the tip of the tongue.

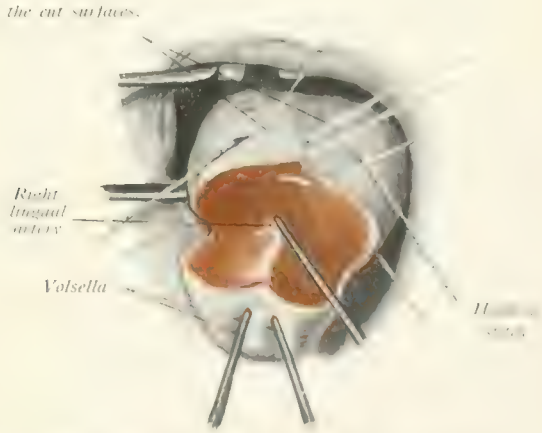
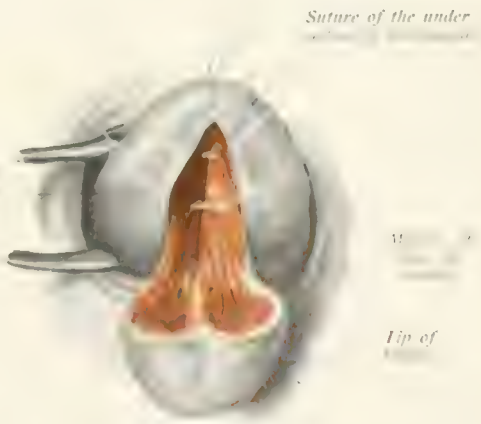


Fig. 365. The tip of the tongue is drawn downward.

Fig. 366. Tying the lingual artery.



condition, and the anesthesia as well as the operation time were made as short as possible. In this case local infiltration anesthesia could not be used on account of the multiple tuberculous ulcerations. To tie off the lingual artery before this operation is unnecessary, if one sutures, as we did in this case, progressively while the excision is being performed.

First the tongue was incised on the dorsum about two-thirds through its substance, and the peripheral portion was seized with toothed clamps and pulled downward (Fig. 365, Plate 65). The wound surfaces starting from the apex of the wedge-shaped defect were immediately approximated with silk, to control the bleeding. As the wound surfaces were united, the incision was lengthened on both sides of the tongue toward the floor of the mouth, in which process the lingual artery on the right side was divided. The spurting vessel was held with a toothed clamp and tied, the same being done later to the left lingual artery as it was met (Fig. 366, Plate 65).

The new-formed tip of the tongue was now elevated by one of the sutures, the ends of which were left long (Fig. 367, Plate 65), and the lower surface to which the almost detached original tip hung now became approachable. As on the dorsum, what was left of the attachments of the tip to the body of the tongue were divided step by step, proceeding from the tip toward the base, to complete the wedge, sewing up as we went along. In this procedure another small artery was injured, but the hemorrhage stopped on suture. After the last remnant of the pedicle was divided, superficial sutures were placed wherever the wound gaped, in order to protect the wound as far as possible from infection with tubercle bacilli, which the patient coughed up in large numbers.

The operation being finished, the silk loops were removed. One end of each of the fifteen musculature sutures above and below was left long and made fast to the cheeks with adhesive plaster, so that the tongue might be immediately drawn out in case edema developed.

The convalescence was without incident. The patient stood the operation well, was fed with fluids by means of a glass tube or invalid cup, and after the third day could swallow without much difficulty, and practically without pain. A week later, after the wound was satisfactorily adherent, he went to pieces from a rapidly progressing tuberculous broncho-pneumonia.

TUBERCULOSIS OF THE TONGUE

Diagnosis in cases such as that described above offers no difficulties. The appearance of the flat ulcers reddened at the edge, and particularly the positive bacterial findings in the discharge, leave no room for doubt. More frequently than at the tip of the tongue, the locus of tuberculous ulcers is at the edges or close to the line where the mucous membrane goes over to the floor of the mouth, and here as the result of pain they hinder all movements of the tongue. They arise out of minor injuries of the mucous membrane, for instance from carious teeth, by infection through the bacteria of the discharge. After removal of the diseased section, one should always extract pointed and sharp-angled stumps of teeth.

Further back in the oral cavity tuberculous ulcers show a preference for the pillars of the soft palate, and here also the high degree of accompanying pain helps to differentiate them from other ulcerations. Syphilitic ulcers, for example, develop absolutely without pain, on the palate as well as on the tongue. In addition to single or multiple ulcers, nodular solitary tubercles are sometimes observed on the mucous membrane of the mouth, particularly at the margin of the tongue. These must also be excised in order to prevent degeneration, sloughing of the tissue of the tongue, and spread of the tuberculosis. Since the diagnosis in nodular tuberculosis of the tongue is often in doubt, excision must be done early in order to rule out carcinoma.

BENIGN TUMORS OF THE TONGUE

To the benign tumors of the tongue which, as a rule, may be extirpated through the open mouth, belongs the condition which, with few exceptions, has been observed only in women called struma of the tongue, or *lingual goitre*. It is located at the base of the tongue, in the middle line near the foramen cecum, and appears under the mucous membrane of the tongue as a vascular blue-red tumor. At first the tumor, which develops from an aberrant portion of the thyroid gland, causes little or no symptoms. But as it grows, either in size or in vascularity, difficulty in swallowing, disturbances in speech, obstruction in respiration, and particularly recurring and continued bleeding on slight injury, are to be counted among the common manifestations.

For its removal, it suffices ordinarily to draw the tongue out by

means of silk loops. On account of the median situation of the tumor, the tongue is split exactly in the middle line. Ordinarily the accessory gland may be shelled out submucously. But if it extends as far down as the epiglottis, as sometimes occurs, one of the methods about to be described, which allow of exposure under direct vision, must be employed in order to forestall a dangerous hemorrhage, and intratracheal etherization, intubation or packing of the pharynx after the method of Kuhn, may be considered advisable.

ACCESSORY INCISION THROUGH THE CHEEK IN THE EXTIRPATION OF TUMORS OF THE MOUTH

Malignant neoplasms within the oral cavity are only exceptionally so favorably situated and so assuredly limited to a small section of the mucous membrane that simple opening of the mouth suffices for their radical extirpation. As already stated, carcinoma situated at the tip of the tongue is to be reckoned in this class. As for other tumors, particularly carcinoma of the base of the tongue, of the palate, cheek, and mucous membrane of the jaw, free approach is necessary, above all things, if one desires to remove all the affected tissue by a wide margin and to protect the patient from an early recurrence.

A simple technique, the transverse division of the cheek after the method of Jäger, is satisfactory for such purpose. If carried out on one or both sides, it furnishes good exposure and free approach to the tongue as far as the base, as well as for neoplasms on the soft palate, and at the alveolar margin of the jaw. The *rima oris* is extended horizontally by splitting the cheek as far as the anterior margin of the masseter, and if necessary this muscle must also be partly divided. The duct of Steno lies above the incision, but it can, if it is extensively injured, be transplanted in the manner described on page 126. In order to reach tumors situated on the dorsum of the tongue or on the palate, a splitting of the cheek on both sides may be considered, with the help of which, naturally, more room for an extirpation may be obtained. As an example of the technique, we present a case of extirpation of a tumor of the palate.

In a forty-two-year-old landowner a hemispherical tumor had developed on the soft palate during the course of two years, which caused considerable difficulty in talking and swallowing. It gradually completely involved the left half, and extended medially to near

the middle line, upward to the border of the hard palate, and laterally to the anterior pillar; below it extended over the tonsil (Fig. 368, Plate 66). The mucous membrane was not ulcerated, but in some places it was intimately adherent, and through it showed a pale yellow discoloration.

An examination showed that the tumor was easily approachable by extending the *rima oris* and could be readily extirpated; the operation was accordingly carried out by the method of Jäger.

To begin with, the tongue was drawn out with silk loops and pulled over to the left side away from the field of operation. The cheek incision ran from the corner of the mouth in the direction of the lobule of the ear, parallel to the margin of the lower jaw. It was carried with one stroke down to the mucous membrane and extended as far as the anterior edge of the masseter muscle; the duct of Steno remained above the incision (Fig. 369, Plate 66). Then, after numerous spurting vessels were controlled by hemostats and ligatures, the mucous membrane was also divided, its edges seized with toothed clamps and laid above and below over the cut margins of the cheek so that no blood could flow into the mouth (Fig. 370, Plate 66). The mucous membrane was divided backward until the edge of the masseter was just visible.

In order to make the surface of the tumor and the surrounding tissue approachable over as wide an area as possible, the mouth was held open by a mouth gag introduced on the normal side, the tongue drawn over strongly to the right, and a wide retractor introduced in the angle of the incision (Fig. 370, Plate 66). By this means the operative field was so exposed that the extirpation of the tumor could be carried out in full view and without hindrance.

Then the normal and non-adherent mucous membrane of the anterior pillar was divided at the external margin of the tumor, and starting from this wound the tumor, together with the tonsil, was freed up from the underlying tissue by blunt dissection with the finger. This technique offered the best protection against injury to the internal carotid artery, which runs very close by, but somewhat external and posterior. Then the entire mass, together with the mucous membrane which was adherent to the tumor, being seized by a circular clamp and turned over to the middle line, the extirpation could be completed by continuing the mucous membrane incision around the tumor and by freeing it up from the posterior pillar with scissors (Fig. 371, Plate 66). The upper mucous mem-

Resection of the soft palate after transverse incision of the cheek (Jäger).

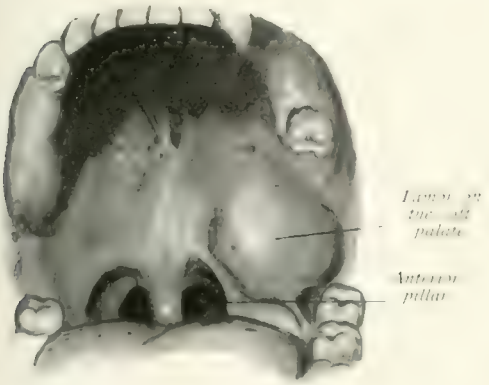


Fig. 368. Location of tumor.

Fig. 369. Transverse division of cheek after Jäger.

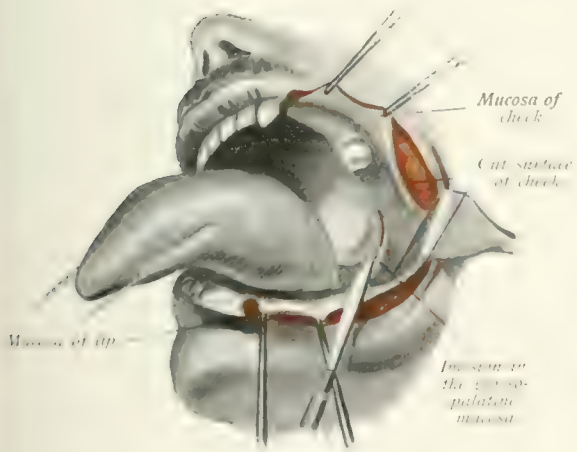


Fig. 370. An incision is made around the tumor.

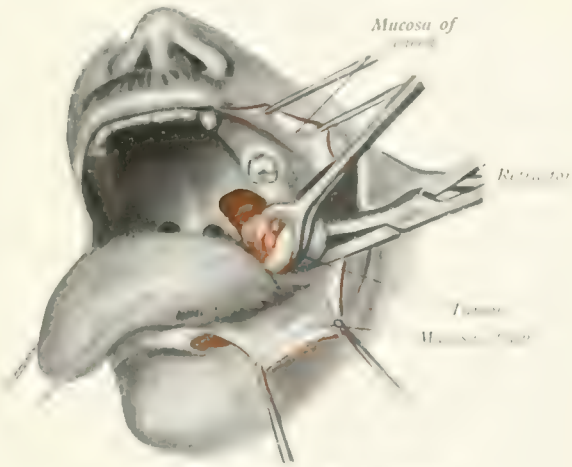


Fig. 371. Extirpation of the tumor.

Fig. 372. Extent of the cavity remaining.

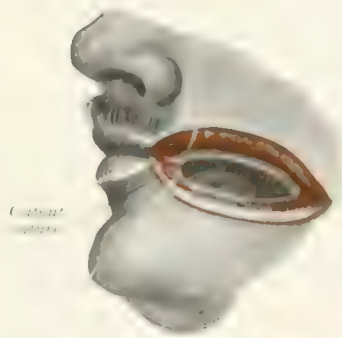


Fig. 373. Suture of oral mucosa.

brane of the soft palate, as well as the layer of the palatal musculature, were preserved.

The venous bleeding from the bed of the tumor was completely controlled by pressure with an iodoform gauze sponge. A plastic closure of the wound of the palate (Fig. 372, Plate 66) was not necessary, as there was no perforating defect which might cause danger, if left unsutured. The open wound of the mucous membrane was accordingly covered with a few layers of gauze and the end carried out of the corner of the mouth, but the transverse incision of the cheek was closed by careful suture (Fig. 373, Plate 66), on the oral side with buried catgut sutures which did not penetrate the mucous membrane, and the skin with silk. On discharge, eight days later, the wound in the cheek was healed by first intention and the wounds in the pharynx showed a clean granulating surface.

Microscopical examination revealed an endothelioma, a typical tumor in this region of the mouth. Clinically this is not to be reckoned with the malignant tumors, for it possesses a sort of capsule, and develops very slowly with little infiltration and without metastasis. After a course of years it may reach a considerable size; it has been observed as large as an apple. These tumors were formerly classified with carcinoma and sarcoma, and sometimes the term cylindroma was employed, as the tissue contained many hyalin cylinders.

Examination several months later showed that the smooth scar on the cheek hardly limited opening of the mouth; speech was unimpeded and swallowing was accomplished without difficulty. The defect in the mucous membrane of the palate had healed with some lineal scarring, as the result of which the uvula was somewhat displaced to the left.

A considerable advantage of the transverse incision consists in the moderate disfigurement and the good functional result. But although a large proportion of resections on the palate and the tonsils can be carried out conveniently and in full view, as the broad approach to the oral cavity makes it possible to prevent all flowing of blood into the air-passages, the Jäger technique does not suffice for all operations within the oral cavity. Even if both lips are split according to the technique of Maisonneuve, carcinomata of the tongue which are not limited to the mobile anterior

section of the organ can, on the whole, be only unsatisfactorily seen and removed; the approach to the base of the tongue is always hindered by the lower jaw. Also for resections on the floor of the mouth as well as for removal of tumors from the cheek, the Jäger technique does not always suffice.

Moreover, even in case transverse division of the cheek gives room enough for radical removal, we must give up this simple procedure if the mucous membrane of the cheek is to be preserved in its entirety, to be employed for plastic purposes. Large defects of mucous membrane and deep loss of tissue within the mouth, with the exception of the roof, should not remain uncovered, for in an open pocket secretions may collect and decompose with resulting infection of the floor of the mouth, the tongue, and the deeper layers of the neck. Moreover, extensive loss of mucous membrane may, through later scar retraction, cause marked restriction in movements of the jaw and opening of the mouth, as well as distortion of the cheek, palate, and tongue. For these reasons the mucous membrane of the cheek should be preserved in the extirpation of such tumors particularly as are located at the line of transition of cheek and gum of the lower jaw, and, moreover, in tumors which develop in the posterior part of the mouth, in the bands of mucous membrane which connect the lower jaw with the palate and upper jaw.

For preservation of the mucous membrane of the cheek, the right-angle cheek-splitting operation of Gersuny is particularly adapted. The following case illustrates its employment:

In a fifty-five-year-old officer there developed in the region of the wisdom tooth of the right upper jaw, on the floor of a leucoplakia, an ulcer with raised edges and hard border. It had grown rapidly in the months preceding his entrance, and had spread from the mucous membrane of the gum to the cheek (Fig. 374, Plate 67). In order to preserve the mucous membrane necessary for a plastic operation, extirpation with a cheek incision after the method of Gersuny was decided on.

The incision ran vertically downward from the corner of the mouth, and at the margin of the jaw turned backward at a right angle and was continued not quite to the angle of the jaw (Fig. 375, Plate 67). After tying all bleeding vessels, particularly the facial artery, the mucous membrane was divided at the lower margin of the cheek pouch, seized with tooth clamps and turned forward,

Rectangular division of the cheek after Gersuny.

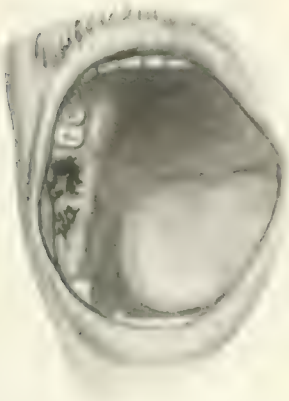


Fig. 374. Carcinoma of the alveolar margin, extending on to the mucous membrane of the cheek.

Fig. 375. Gersuny's incision.

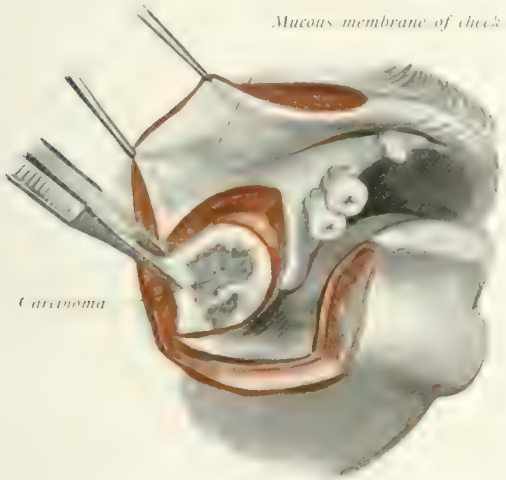


Fig. 376. Excision of the neoplasm, and dissection of a plastic flap from the mucous membrane of the cheek.

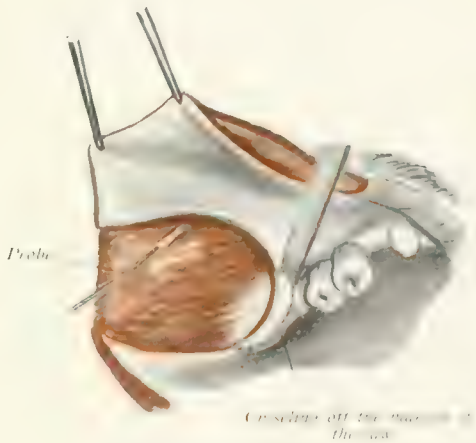


Fig. 377. Probe in Steno's duct.

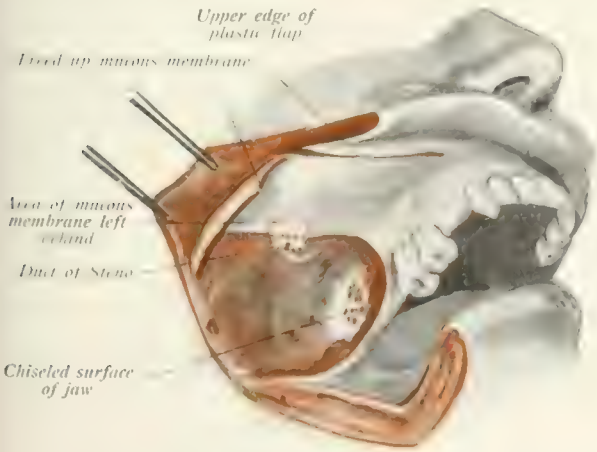
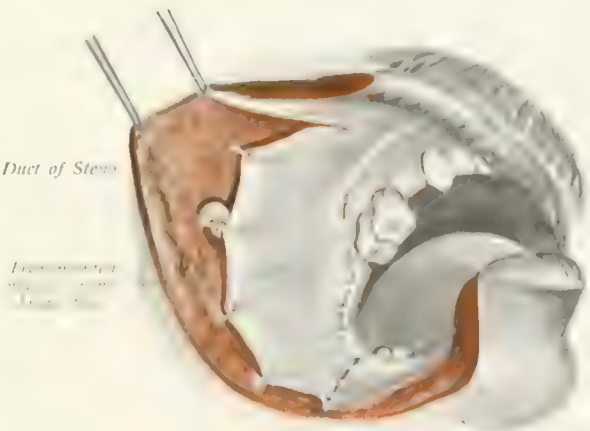

Upper edge of plastic flap
Turned up mucous membrane
Area of mucous membrane left behind
Duct of Steno
Chiseled surface of jaw

Fig. 378. Transplantation of the duct of Steno, and its suture, after being split longitudinally, to the deep tissues further back.



membrane flap.

so that the carcinoma was visible in its entire extent (Fig. 376, Plate 67), and could be excised with a wide margin of normal tissue. The incision being made around it, it was freed up from the underlying strata with scissors and raspatory, and in order to be assured of complete removal, the superficial layer of bone was chiseled off from the lateral wall of the alveolar process.

Within the limits of the circular incision there fell the orifice of the duct of Steno, although this lay more than 1 cm. above the palpable margin of the carcinoma. A probe was passed into the duct (Fig. 377, Plate 67) and was allowed to remain until the transplantation was completed. About this probe the duct was freed up from the cheek without injury by blunt dissection with the aid of a few snips of the scissors, the end was slit upward for a short distance, and the two tiny flaps thus formed were sewed with fine silk far back into the mucous membrane and deep tissues (Fig. 378, Plate 67). On the transplantation of the plastic mucous membrane flap later a crescentic portion of mucous membrane to which the new orifice had been sutured was left behind in order not to endanger the fixation of the sutures.

After extirpation of the carcinoma there remained a defect about the size of a silver dollar, which extended downward to the fold between the cheek and the gum. To cover this defect, a flap of mucous membrane was taken from the portion of the cheek which had been turned upward. Its pedicle lay at the alveolar process of the upper jaw, and its upper edge beginning near the right upper canine tooth, ran into the upper lip. The lower edge corresponded to the upper extirpation incision of the carcinoma (Fig. 378, Plate 67). By twisting this flap ninety degrees, it could be turned into the defect without tension so that its lower margin fitted into the wound of the gum, and the free upper edge could be sutured all over the exposed area without distortion (Fig. 379, Plate 67).

The wound surface which remained could be diminished in size by mobilization of the surrounding mucous membrane, and by drawing it together with catgut sutures. This was the more readily accomplished on account of the great elasticity of the mucous membrane of the mouth and lips, and its loose union with the underlying tissue. After the wound surfaces in the mouth were practically entirely covered with mucous membrane in this manner, the external incision running from the angle of the mouth toward the angle of the jaw was closed with buried catgut and skin suture.

The patient was discharged after nine days with the wound healed. Four weeks later a few small suspicious nodes appeared at the angle of the jaw on the right side, and they were cleaned out. Even at this time the patient could open and shut the mouth nearly as well as before; he was left with no disturbance in movement of mouth and jaw.

Examination three years later (Fig. 380) showed that the patient had remained free from recurrence. Of the incision through the cheek, at this time only the vertical limb was visible as a slightly retracted scar; the line running horizontally backward along the

FIG. 380

Scar on cheek, three years after the Gersuny operation.

margin of the jaw was recognized with difficulty. In the mucous membrane of the cheek, a few bluish-colored scars were visible. On talking and chewing, as well as on other motions of the mouth, the patient felt no sense of tension.

PLASTIC RESTORATIONS OF DEFECTS IN THE ORAL MUCOUS MEMBRANE

The mucous membrane of the cheek and lips may be very conveniently used for covering defects on account of its elasticity, its loose connection with the underlying tissues, and particularly on account of the assurance with which wounds within the oral cavity heal after transplantation. But if the wound, after extirpation of a neoplasm, is extensive, a portion at least may be covered with a flap of mucous membrane; taking into account the active tendency to

healing of all wounds within the mouth, the rest of the cheek and lip defect may be left to cover in by granulation and secondary scar tissue. For covering a wound one can take a surprisingly large amount of the neighboring mucous membrane, particularly if, according to Lexer, he uses the mucous membrane from the floor of the mouth and tongue.

The attempt to cover defects on the inside of the cheek by the means of Thiersch grafts usually fail. The transplants fall off on account of the constant mobility of the cheek and the moisture, and if they should heal on, they could not prevent shrinking of the cheek, and contracture of the jaw. If one wishes to employ the plastic procedures such as have been described in Volume I, the pediculated skin flap may be used, which according to Israel should be taken from the hairless portions of the neck or, according to Bardenheuer, from the forehead or by doubling the skin of the cheek.

The Gersuny incision just described may also be employed for the purpose of turning a pediculated skin flap in to cover the mucous membrane defect. For this purpose a piece of skin of the neck, corresponding in size to the defect, is cut from the horizontal limb of the incision, which runs toward the angle of the jaw. This plastic flap maintains its connection with the underlying strata alone at the margin of the jaw above, its pedicle being composed only of subcutaneous and muscular tissue. Otherwise the flap is entirely freed from the underlying strata, twisted upward one hundred and eighty degrees, and is fitted into the defect. Its epidermal layer is directed inward toward the mouth. The secondary defect in the neck is closed by Thiersch grafts or, better still, by drawing the wound edges together and suturing.

The advantage of this procedure is that all the diseased glands can be removed through the wound in the neck at the same time the plastic operation is completed. A possible disadvantage consists in the fact that the piece of skin which is turned into the oral cavity is poorly nourished and is liable to the danger of necrosis. Naturally this method cannot be used if the skin of the neck below the transverse incision is bearded. With the other methods the oral cavity must be left open, to be closed at a later sitting, and, moreover, an opening must be left near the pedicle. As a result, taking of nourishment by the natural means is rendered difficult, as food and drink continually flow over the wound surfaces and out through the fistula.

In conclusion, it should be said that Schmieden has recommended the Italian method of taking the skin from the arm for the restoration of the mucous membrane of the cheek. He obtained a favorable result by placing hairless skin from the upper arm into the oral cavity through an incision in front of the ear, and fastening it into the defect. It healed in completely after cutting the pedicle, and the hole through the cheek closed without forming a fistula

LEUCOPLAKIA

As frequently happens, the carcinoma of the oral mucous membrane in the case which we have just described (p. 364) develops on the base of a leucoplakia. A year after extirpation of the neoplasm two definite plaques developed on the left cheek, and they were excised under local anesthesia by means of an elliptiform incision and the wound closed by primary suture. This radical procedure seemed to be the more indicated as the place where the carcinoma developed had previously been treated by others repeatedly with caustics, the galvano-cautery and by other insufficient and, on account of the time which is lost with their employment, dangerous methods.

Schuchardt demonstrated the relationship between carcinoma and leucoplakia. The connection which may be observed in our case of carcinoma of the cheek and jaw holds likewise for the origin of carcinoma of the tongue, where leucoplakia is more frequently observed than anywhere else in the oral cavity. Although it was formerly believed that these chronic changes of the mucous membrane occurred only in smokers, and particularly in men, the compilation of Butlin * shows that women also evidence exactly similar changes of the mucous membrane of the tongue and cheek. From what at first are small opaque white spots in the mucous membrane of the cheek or on the anterior section of the surface of the tongue, there develop gradually wide white streaky maplike indurations, which, as a rule, are slightly elevated from their surroundings. Later they grow harder and may affect a large portion of the mucous membrane and be covered with rhagades which bleed readily. Although these spots cause only slight difficulty, so long as they are not of great extent, nevertheless, on account of their location, they cause a good deal of trouble as they grow larger, and they may give rise to severe pain on talking as well as eating.

* British Medical Journal, February, 1909.

According to Jakobi, leucoplakia has nothing to do with syphilis, as the spots are in no way influenced by anti-specific treatment, and in comparison with syphilitic plaques, also, the extremely chronic development of this disease is characteristic. On account of this dangerous relationship with the development of carcinoma, we have put aside at the present time the mild caustics such as chromic acid or silver nitrate, which only destroy the superficies and leave deep epithelial layers untouched, as well as the energetic and painful cauterants such as were recommended by Volkmann, and employ by preference excision of the horny spots with the knife, particularly as the operation can always be carried out under local anesthesia.

CARCINOMA OF THE MUCOUS MEMBRANE OF THE TONGUE AND MOUTH

According to general observation, carcinoma of the tongue and mouth arises by preference not only on the base of a leucoplakia, but upon the floor of chronic ulcerations of the mucous membrane which have originated through carious teeth or chemical irritants, particularly tobacco. Heredity as well as early luetic infection are also commonly considered of etiologic moment. Women are affected much less frequently than men, although figures vary in different countries and localities. In England, for example, and in the north of Germany, carcinoma of the tongue is more frequent in women than in Austria and in the Orient, although here women are accustomed to smoke as well as men.*

As to location and extent, cancerous growths are limited in only infrequent cases to the tip of the tongue and the mobile anterior portion, that is to say, to the section where radical removal may be performed without the necessity for accessory incision through the cheek and jaw.. The symptoms of a neoplasm in this situation depend upon the occurrence of a nodular thickening or of a sloughing papular ulcer on the tongue. In addition speech and the taking of nourishment are somewhat hindered.

Carcinoma develops much more frequently on the lateral margin or at the base of the tongue near the epiglottis than on the tip. But while carcinoma growing on the tip makes itself known early as the result of the difficulty in talking, the tumor develops on the margin of the tongue or near the epiglottis, as a rule, without attracting attention in the form of a submucous infiltration of the

* Ehrlich, Archiv. f. klin. Chir., 1909, Vol. 88.

tissue which becomes harder and harder. It may remain concealed for a long time under a leucoplakia, until one day the destruction of the infiltrated portion of the tongue starts from the edge of such a patch.

In addition to submucous infiltrations, cancerous foci are observed also in the deep-lying portions of the tongue where they arise from the glands which project far into the musculature, and which are at first palpable as hard nodules. They may be confused with chronic abscess, inflammation about a foreign body, and gummatous tumors. These foci gradually find their way to the surface, break down, and then cannot be differentiated from the other rigid-walled cancerous ulcers.

There is still a third and much less frequent form of carcinoma which occurs on the tongue, the papular hypertrophic growth at the base of the tongue near the epiglottis, at the place where the mucous membrane of the tongue runs into that of the soft palate. Microscopically this is no different from the other forms. As leucoplakia practically never involves the posterior section of the surface of the tongue, this important index to the diagnosis of carcinoma is wanting in such cases; accordingly, carcinoma in this situation is not recognized, as a rule, until it has become inoperable, on account of its extent.

Just as varied as the onset of the affection may be its further development. The destruction may remain limited locally for a long time, but it is just as likely to spread rapidly from its original seat on the margin of the tongue and involve the floor of the mouth, the palate and cheek. From large ulcerations, active hemorrhage frequently arises, even after minor injuries during mastication, and decomposition of the secretions and of the necrotic tissue occurs. The condition is still more distressing if the advance of the cancerous infiltration is combined with severe neuralgic pains which radiate to the jaw, the ear, or to the occiput. This may be the case even with small foci, in which the pains arise from the inflamed and infiltrated edge of the ulcer, which is irritated by every movement of the tongue. On the other hand, the development of carcinoma centrally situated deep in the mass of the tongue, particularly in the anterior section, may proceed entirely without pain, so that such patients remain for a long time in ignorance of their disease.

On account of the rich supply of lymph vessels in the tongue and their extensive system of branches, carcinoma of the tongue is likely

to involve the regional lymph nodes early. According to Küttner, the lymph stream flows outward in many directions: into the lymph nodes under the chin, at the margin of the jaw, into the deep nodes of the neck, and even to those situated near the clavicle. In the extent of this network consists the gravest danger of cancer of the tongue. For there exists no rule for the involvement of the single groups of glands, and on the other hand the glands may be affected out of proportion to the small size of the focus. Moreover, the neoplasm may be situated on one side of the mouth and extensive metastasis occur on the opposite side of the neck.

Nevertheless, for the determination of the question whether or not a carcinoma of the tongue or mouth is still to be considered operable, the wide extent and the distribution of the affected lymph nodes is no standard. For, according to the anatomical investigations of Küttner,* all these regions in the neck lie only in the first stage of the final distribution of the lymph stream. The large number of recurrences, even after radical removal of the primary focus and of all palpable metastatic nodes, particularly when they occur in the lymph apparatus, while no recurrence can be demonstrated at the primary site of the disease, are readily explained by the richness and extent of the lymph tracks. If the lymph nodes are overlooked on account of their small size and soft consistency in cleaning out the neck or the area below the jaw, they develop later within the region of the incision and appear as a recurrence within or near the scar.

The manifestations and clinical course of cancer of the palate are similar to those of carcinoma of the tongue and of the floor of the mouth. This usually arises at the edge of one of the tonsils or in its mucous surface and then develops into a hard nodule which may break down and form a foul and gaping tonsillar ulcer. Like carcinoma of the tongue, the increase in size is accompanied by active pain, particularly in the ear, hemorrhage from the destroyed tissue, and early and widespread infection of the corresponding lymph nodes. Among these, in the usual unilateral situation of the neoplasm, are the nodes of the same side of the neck, particularly those which lie near the internal carotid artery, and the corresponding retromaxillary glands.

For *diagnosis*, in addition to the anatomical picture of the deep ulcerated surface with hard and elevated margin, the painlessness,

* Beiträge z. klin. Chir., Vol. 21.

particularly at the beginning, and the absence of fever, are of significance. To rule out a broken-down gumma, which develops more rapidly and is more commonly bilateral, the Wassermann reaction may be taken, or antiseptic treatment employed. The most positive information is given, naturally, by a small section removed

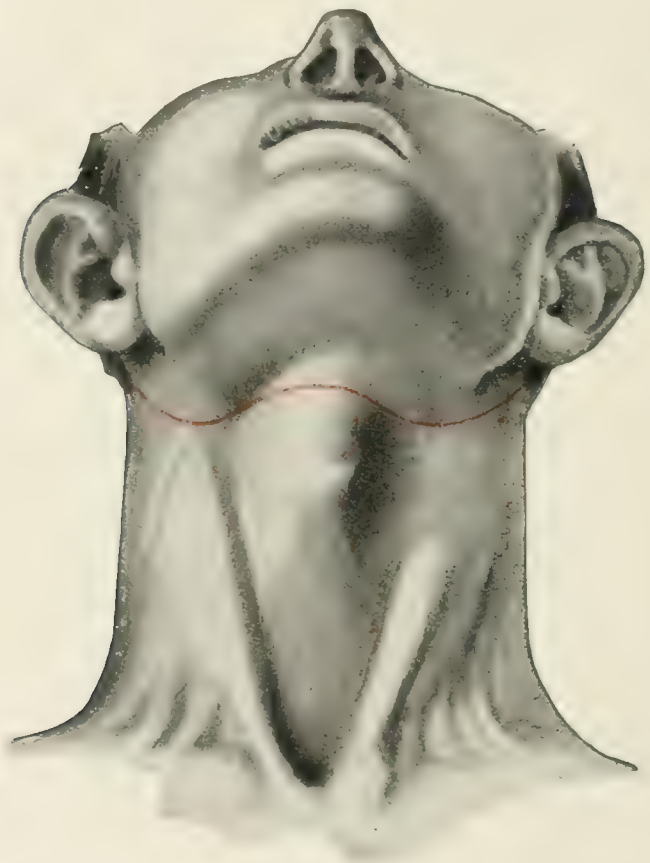


FIG. 381

Collar incision for clearing out the lymph nodes from the neck.

for diagnostic purposes. Carcinoma of the palate, particularly when developing behind the tonsil, may for a long time evade recognition, and a careful examination made on account of enlarged nodes in the neck, pain on swallowing or neuralgic pain in the face and ear, may reveal on palpation of the corresponding side of the palate a nodular induration in the region of the tonsil, or a stiff walled ulcer with a foul smelling secretion.

PROPHYLACTIC EXCISION OF THE LYMPH NODES OF THE NECK

Operative treatment of carcinoma within the oral cavity should begin with the cleaning out of the lymph nodes of the neck and, on the basis of the investigations of Küttner, this should always be bilateral. In the preparatory operation, the superficial nodes

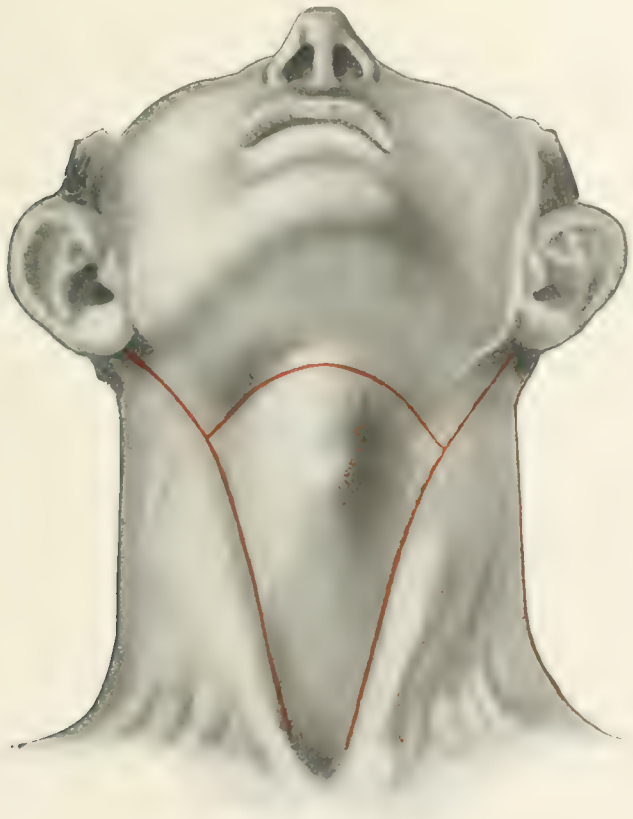


FIG. 382
Inverted A incision.

along the internal jugular vein as well as the deep nodes along the carotid artery and those which lie below the mastoid, should be extirpated, as well as the submental, submaxillary, and supraclavicular nodes. On account of the rich lymphatic network surrounding the submaxillary glands, which drains the oral cavity, both these glands should also be removed. This may be done by various methods, the choice depending upon the incision chosen for

the extirpation of the primary carcinoma. For reasons of asepsis, the wounds made in cleaning out the lymph nodes should be sewed up tight.

The extirpation of the nodes should be done first and the resection in the oral cavity should follow. For the fine meshes of connective tissue in the neck may be readily infected from a wound

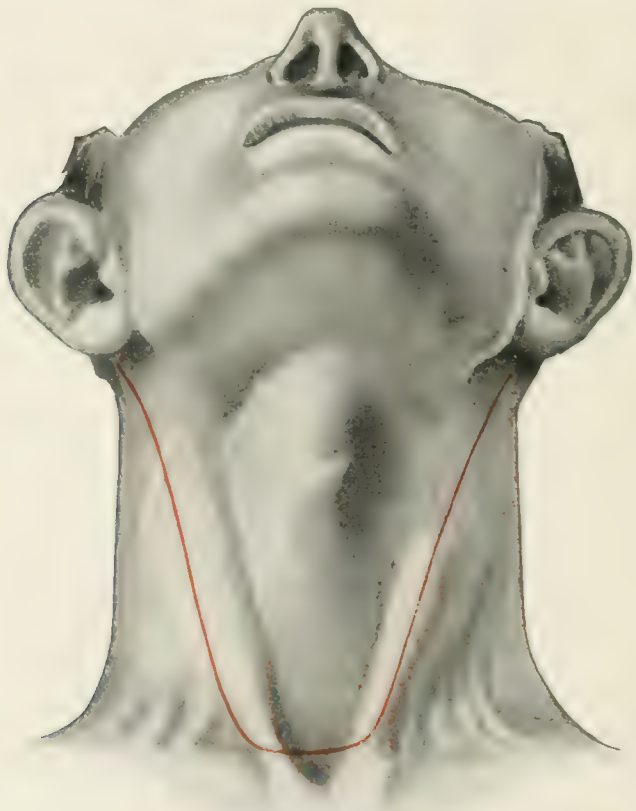


FIG. 383
Krause's incision.

communicating with the oral cavity. If the order of procedure is reversed, a secondary cellulitis may arise in the neck, with fatal termination.

Ordinarily the simple collar incision (Fig. 381) is employed for resection of the lymph nodes. This goes from one mastoid down behind the ramus of the jaw along the anterior margin of the sterno-mastoid and curves forward along the hyoid bone to the other. After dividing the skin platysma myoides and superficial

fascia of the neck, these parts are freed above and below from the underlying tissue in the form of flaps, and the lymph nodes along the great vessels in the submaxillary region and particularly between the muscles of the floor of the mouth are sought out and removed. Then the two skin flaps are replaced and sutured without drainage, in order to obtain primary wound healing.

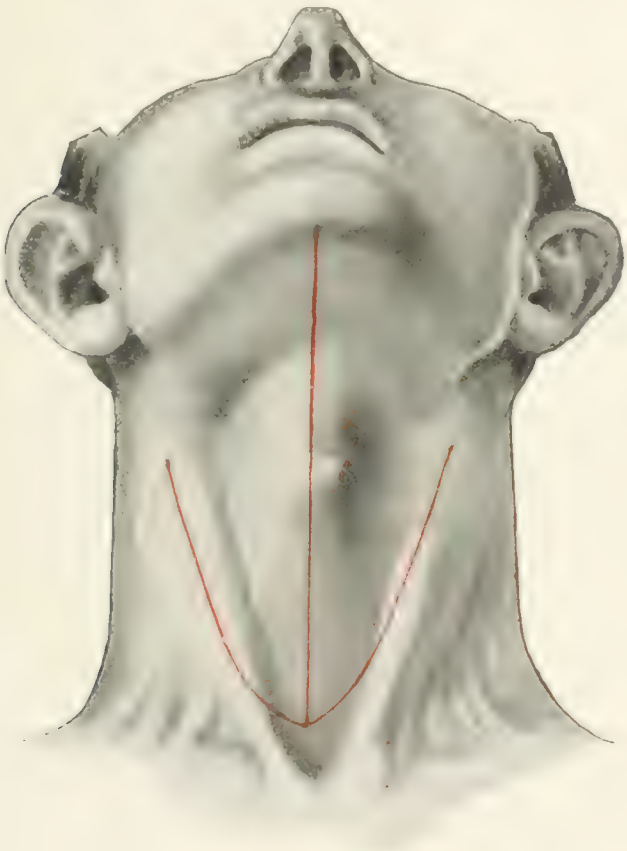


FIG. 384
Butlin's incision.

In extensive involvement of the nodes, an inverted A incision is commonly employed (Fig. 382). Its lateral limbs run down on each side along the anterior margin of the sterno-mastoid to the region of the clavicle, and are connected by a transverse incision running below the hyoid. Instead of this incision preference may be given to a large right-angle flap, the base of which, as in Fig. 383, lies between the two mastoid processes, the sides corre-

spond to the anterior margins of the sterno-mastoids, and the lower edge runs transversely about the suprasternal notch. Butlin makes two triangular flaps (Fig. 384), the apices of which lie in the suprasternal fossa; a median incision runs from the apex of the chin and to the suprasternal fossa, and an oblique incision runs on either side from the lower end of the median incision upward

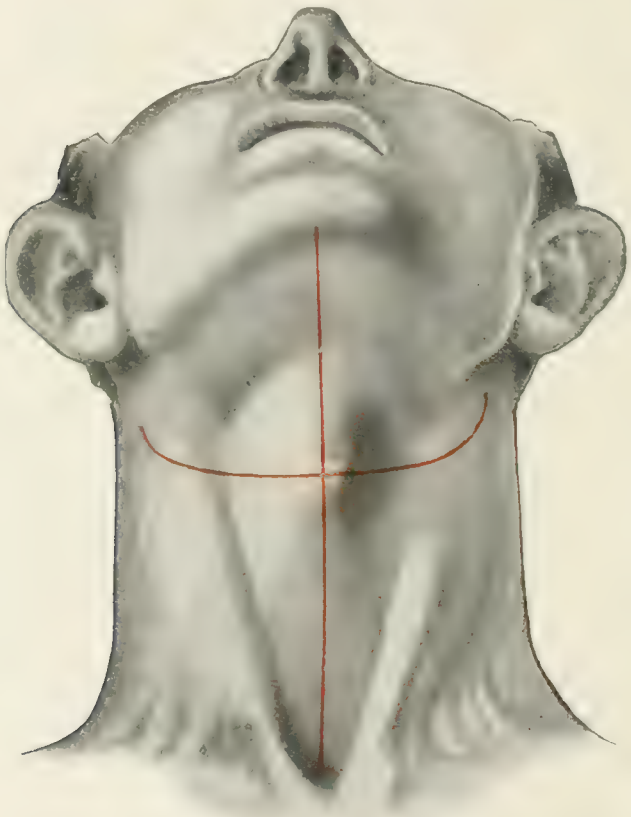


FIG. 385
Küttner's incision.

along the margin of the sterno-mastoids. Küttner uses a crucial incision (Fig. 385), making four flaps with apices in the region of the larynx, which are freed up in all directions.

As a drawback of such extensive dissection of the lymph nodes may be mentioned the permanent swelling of the face which occasionally occurs, as the result of lymph stasis, and this, among other disadvantages, causes difficulty in chewing. But on the other

hand the smallest remnant of carcinoma left behind means certain recurrence. The optimistic view that the organism can overcome small foci of malignancy is not tenable, and it is wise to proceed as radically as possible in extirpating the nodes. Not only are the large vessels and nerves of the neck exposed, but the internal jugular vein and the sheath of the common carotid should be resected, if there are nodes in intimate relation to them. Also all loose connective tissue is most carefully removed from the floor of the mouth down to the suprasternal notch, taking care that no nodes are left behind in the depths in front of the mastoid process.

Through the incision which has been selected, ligation of the external carotid artery may be done if necessary, for instance, in large neoplasms at the floor of the mouth, but the lingual artery should always be tied on both sides (see Fig. 358). Even if the preparatory operation does not seem absolutely necessary, no disadvantage attaches to the ligation of this vessel, and as the result of the local anemia, the resection of the tongue may be performed under better visual conditions. But the ligation must be done on both sides, as on account of the rich anastomosis secondary hemorrhage may occur from the stumps of the vessels which did not bleed during the resection.

RESECTION OF THE TONGUE BY THE SUBMENTAL ROUTE

In all cases in which the neoplasm does not lie on the mobile section of the tongue or on the mucous membrane of the jaw or cheek, a direct approach from without must be established. The submental incision with division of the floor of the mouth from the lower jaw, and drawing the tongue through below, which was invented by Regnoli and Billroth and was formerly widely employed, has now been practically abandoned. Its chief disadvantage lay in the fact that the muscles running from the jaw and the hyoid bone were divided transversely with the resulting disturbance of swallowing and an increase in the danger of pneumonia and suffocation.

Von Bergmann recommended unilateral division of the floor of the mouth through an incision such as is employed for ligation of the lingual artery. It must be extended outward to the sternomastoid to allow room in which to undertake the cleaning out of all diseased cervical lymph nodes, and medially far enough so that

the digastric muscle may be split or at least drawn forward with a blunt hook. After dividing the platysma and the superficial fascia of the neck, the submaxillary gland with all the lymph nodes within reach is removed, the lingual artery divided, and the mylohyoid muscle separated on the inside from the margin of the jaw. Then the mucous membrane is separated from the jaw by blunt dissection and divided. The tongue and the freed up portions of the floor of the mouth may then be turned down through the wide opening and resected for such extent as seems necessary.

A better view and easier approach to all parts of the oral cavity may be obtained by temporary division of the jaw, after the method of Langenbeck. This, in its original form, at least for the extirpation of tumors of the tongue and pharynx, has been abandoned for the modified methods of von Bergmann, but in tumors limited to the cheek or the anterior portion of the floor of the mouth, the original incision may be the better, particularly if it is a question of preserving the mucous membrane of the cheek *in toto* for plastic purposes. The method of Langenbeck may be demonstrated by the following case in which a carcinoma of the tonsil was removed and the defect covered by a plastic flap.

OSTEOPLASTIC RESECTION OF THE LOWER JAW FOR EXPOSURE OF THE ORAL CAVITY, ACCORDING TO LANGENBECK

A sixty-nine-year-old laborer five weeks before entrance noticed a hard bunch the size of a quarter dollar near the left tonsil, which bled readily on swallowing and caused pain. In spite of gargles and local treatment the tumor increased in size. On examination of the mouth, there was seen a tumor the size of a half dollar with a broken down surface, on the left anterior pillar. Histological examination of a bit of loose tissue showed squamous cell epithelial cancer. At the floor of the mouth upon this side a few hard nodes could be felt.

Transverse incision of the cheek would not have sufficed to allow us to reach the lateral wall of the pharynx and the base of the tongue in this patient. Accordingly division of the jaw was undertaken. A vertical incision was made through the skin running from the left corner of the mouth to the periosteum of the jaw (Fig. 386, Plate 68). Periosteum, platysma and the fascia of the neck were divided, and the submaxillary gland, after division of some of its veins, was dissected bluntly from its muscle bed. In

Osteoplastic resection of the lower jaw for exposure of the oral cavity, after v. Langenbeck.

Fig. 386. Incision downward from angle of mouth, after v. Langenbeck; freeing up of mucosa from oral side of jaw.

Fig. 387. Sawing through the jaw.

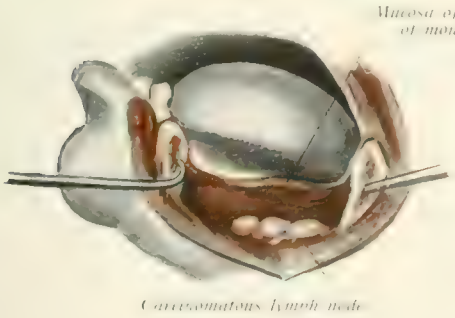


Fig. 388. The fragments of the divided jaw are drawn apart.

Fig. 389. Exposure of floor of mouth.

Fig. 390. Exposure of the lingual nerve.

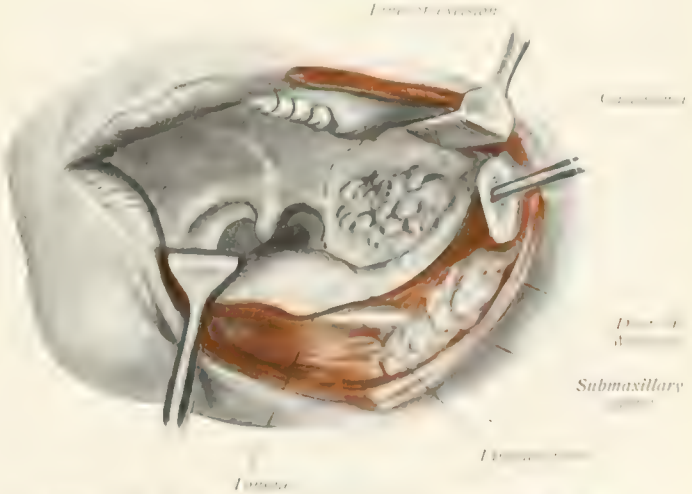


Fig. 391. The base of the tongue and the soft palate are rendered visible and approachable for removal of the tumor.

Plastic on the mucous membrane of the palate, and suture of the jaw.

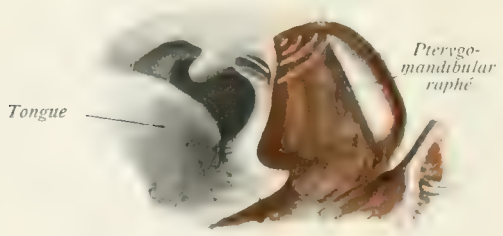


Fig. 392. Direct suture of the mucosa to cover defect above.

Fig. 393. The corner of mucous membrane is freed up and sutured to the pterygo-mandibular raphé.

Fig. 394. The lowest section of the defect is covered by mobilization and fitting in of the small flap of mucous membrane.

Fig. 395. Suture of jaw with wire.

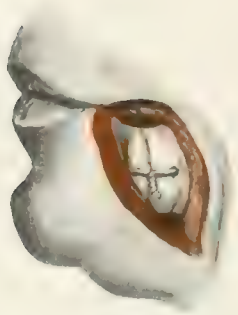


Fig. 396. The wire twisted up, after approximation of fragments.

Fig. 397. Condition after 4 weeks.

cases in which the neoplasm starts upon the tongue or spreads to involve it, which would make resection of the tongue necessary, the lingual artery can be exposed at this point and tied. After freeing up the periosteum for a narrow space on the outer and inner surface of the jaw, a Gigli saw was drawn through by means of a dissector passed up behind the jaw-bone, and the bone sawed through from within outward in the neighborhood of the second premolar tooth (Fig. 387, Plate 68), which was wanting in this patient. Then the two cut ends of the jaw were drawn apart by means of strong hooks which were set in each fragment into the inferior dental canal (Fig. 388, Plate 68).

The swollen and somewhat indurated nodes of the floor of the mouth now appeared lying on the wound surface, and were freed up from the underlying strata and left in connection with the submaxillary gland. In order to separate the bone ends still further and to enlarge the approach to the base of the tongue, the muscles of the floor of the mouth were divided with scissors (Fig. 389, Plate 68). Thereupon the lingual nerve was exposed in its course, in order to avoid injuring it (Fig. 390, Plate 68). The tongue now being depressed, the carcinoma lay freely visible in its entire extent, and practically on the surface of the operative field (Fig. 391, Plate 68).

The neoplasm involved the neighborhood of the tonsil and went far over onto the mucous membrane of the soft palate. Before its removal, the mass of glands at the floor of the mouth had first to be freed up with scissors and forceps and removed. Then the tumor was cut out with a wide margin, starting on the outer side, because from this side passage of blood into the air-passages could be most easily prevented. The tumor then was cut away above and below, and in connection with the tonsil was freed up largely by blunt dissection from the underlying tissue. Finally it remained hanging on the median side to the anterior pillar only by a bridge of mucous membrane and muscle. The entrance to the larynx was clearly visible on cutting this last bridge. On cutting the mucous membrane in the neighborhood of the epiglottis, blood could best be prevented from flowing down by lifting the epiglottis up on a sharp hook.

After removal of the tumor a considerable defect remained (Fig. 392, Plate 69). At the medial edge it could be partly closed by pulling the mucous membrane over and sewing it with four cat-

gut sutures. Then to cover it, the easily movable cut edges of the mucous membrane of the palate and of the floor of the mouth were united above and below with the pterygo-mandibular raphé, which had been exposed in extirpating the tumor (Fig. 393, Plate 69). After tying the stitches which had been thus placed, the uvula stood exactly in the middle line, considerable care having been exercised in sewing the mucous membrane. The section of the defect which now remained below was closed by pulling up and sewing in a corner of the mucous membrane of the mouth (Fig. 394, Plate 69).

After covering the defect, three catgut sutures were placed through the mucoperiosteal covering on the inside of the jaw, but they were not tied as the two cut ends of the jaw-bone had first to be united with silver wire (Fig. 395, Plate 69). When this had been done the three sutures were tied on the inside and the periosteum was sewed over the silver wire, and the lip was closed with catgut and the skin with silk. There was a small defect of mucous membrane remaining in the mouth near the tongue. It was packed with iodoform tape, and on account of the lack of absolute asepsis, the end was brought out, together with a short drainage-tube, through the lower angle of the incision.

On the third day the stitches were removed and soon after the drainage. When the patient left the hospital, four weeks after operation, the wound in the pharynx had healed smooth and the incision on the left lower jaw had closed except for a granulating area the size of a pea. His condition was, therefore, as shown in Fig. 397, very good.

OSTEOPLASTIC RESECTION OF THE LOWER JAW WITH EXPOSURE OF THE ORAL CAVITY, ACCORDING TO VON BERGMANN

As compared with the original technique of Langenbeck, the modification which von Bergmann introduced has considerable advantages. It procures a still wider opening of the oral cavity, inasmuch as it combines the advantages of the temporary resection of the jaw with those of transverse incision of the cheek, and a complete removal of the lymphatic system of this neighborhood is made possible.

The modification of von Bergmann is indicated in all neoplasms of the posterior section of the tongue and of the floor of the mouth, also if the tumor lies in the region of the epiglottis. If

Osteoplastic resection of the lower jaw for exposure of the oral cavity after E. v. Bergmann.

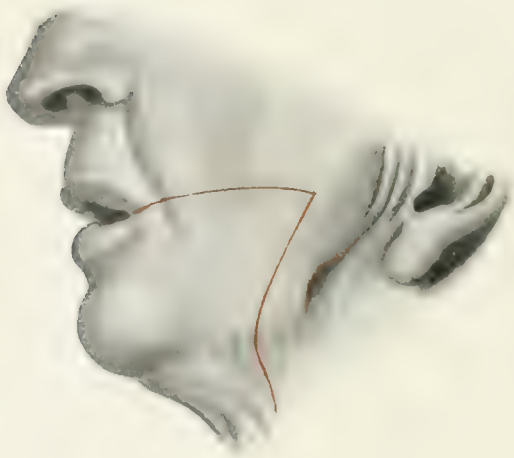


Fig. 398. v. Bergmann's incision.

Fig. 399. Dividing the jaw with a Gigli saw.

Fig. 400. The divided jaw is drawn apart, and the hard palate chiseled away.

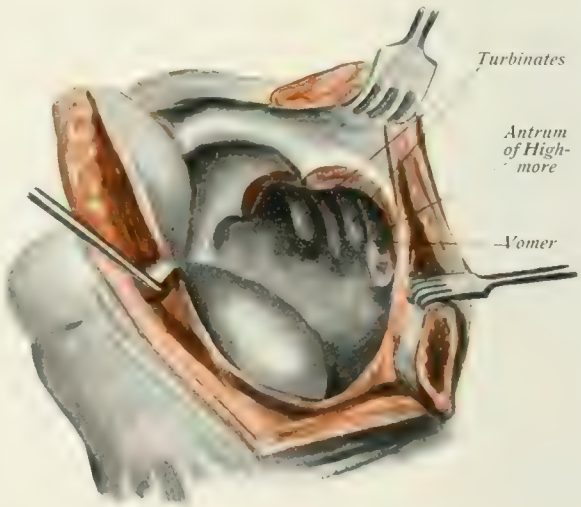


Fig. 401. Extent of wound cavity.

Fig. 402. Uniting the fragments of the jaw with wire.

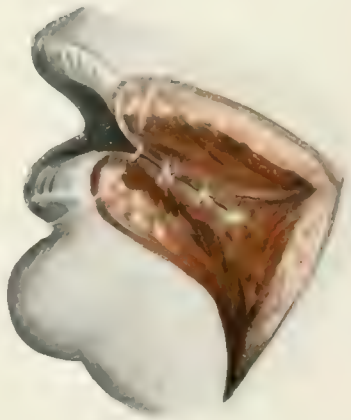


Fig. 403. Suture of cheek.

the wall of the pharynx is involved or if operation has been necessary for recurrence on the soft palate, after dividing the cheek and the body of the jaw, the base of the tongue and the epiglottis lie practically on the surface of the operative field, and by depressing or drawing out the tongue the entrance into the air-passages may be kept in full view. For that reason tracheotomy with the tampon cannula, the intubation method of Kühn, or intratracheal insufflation, may not be necessary to prevent aspiration of blood and mucus, although the later method gives an even anesthesia and an unobstructed operative field. But if on account of the extent of the resection a protective packing of the entrance to the larynx becomes necessary, it is sufficient after dividing the jaw to cocainize the epiglottis and the entrance to the larynx in the semi-conscious patient, to pull up the epiglottis on a hook and to insert a medium-sized soft rubber catheter through the larynx into the trachea. Then the pharynx may be packed about the catheter with gauze.

By running the transverse incision in the cheek far backward, and the descending limb of the skin incision obliquely forward, a much wider surface of the jaw may be exposed for sawing. Langenbeck previously approved of oblique division of the jaw, because after union of the two ends of bone, the muscle pull in opposing directions on the fragments prevented their displacement. The chin portion of the jaw is pulled downward by the muscles of the floor of the mouth, while the portion which remains connected with the ascending ramus is displaced upward by the muscles of mastication, so if the sawed surface is in a plane running downward and forward (Fig. 402, Plate 70), the ends of the bone are pressed against each other instead of being separated by the normal muscle pull. Displacement of the fragments of the divided jaw may be still further discouraged if the sawn surface is further tilted so that the cut surface of the posterior segment, instead of facing upward and forward, faces upward, forward and outward, for the pull of the muscles of mastication tend not only to displace the posterior fragment upward, but also outward.

The following case demonstrates the incision through the cheek and the method of dividing the jaw.

A seventy-two-year-old patient had been operated upon several times by others for cancer of the palate, and the uvula and pillars of the left side had been removed. Recurrence had developed some

months previously, and on admission to the hospital, it had reached the size of a half dollar, and had extended from the lateral wall of the pharynx to the alveolar process of the upper jaw and the hard palate. The patient was very weak, and as the result of loss of blood was extremely anemic. On account of its nasal quality his speech was almost incomprehensible, and swallowing and talking caused him considerable pain.

At operation the cheek was divided transversely down to the mucous membrane, starting from the left corner of the mouth. At the anterior margin of the masseter the incision was directed downward at an acute angle, the soft parts divided down to the submaxillary region (Fig. 398, Plate 70), and all bleeding vessels ligated. At the margin of the jaw the facial vein and artery were double tied and divided. The periosteum of the jaw was divided in a line directed downward and forward, at the same time with the incision of the soft parts, and was freed up a little ways in front of and behind the incision with a raspatory (Fig. 399, Plate 70). It was freed up somewhat from the bone on the inner side also, so that a Braatz guide could be carried around the jaw with a Gigli saw.

In sawing through, a tongue-shaped process was first formed below (Fig. 402, Plate 70). Then the saw was so managed that the cut surface of the bone ran obliquely backward and upward, and also backward and outward. Then the mucous membrane of the cheek having been divided, the two cut ends of bone could be pulled apart with hooks and the submaxillary region cleaned out in the manner already described (see p. 313). The approach to the oral cavity and to the lateral and posterior walls of the pharynx was now satisfactory and the carcinoma lay within easy reach. The mucous membrane of the palate and alveolar process was incised and freed up 2 cm. from the tumor. The involved portions of the hard palate were removed by a few strokes of the chisel and the extirpation completed (Figs. 400, 401, Plate 70).

On account of the desperate condition of the patient a plastic covering of the defect of the palate had to be neglected, and the entire wound cavity was accordingly packed with iodoform gauze. Finally, the bone ends were united with aluminum bronze wire and the mucous membrane of the floor of the mouth and cheek with interrupted sutures. All buried stitches were of catgut, placed without penetrating either floor of mouth or mucous membrane

of cheek (Fig. 403, Plate 70). The vermilion border and the skin were sewed with silk.

The patient stood the superficial anesthesia in which the operation was carried out, and in which hardly any blood was lost, reasonably well, but he died the next day from weakness.

It must be said of the technique of suture of bone that there is distinct advantage in making the drill-holes before sawing the bone. As long as the lower jaw is intact, the drill can be used to better advantage and the holes placed in proper relation to each other. In order to prevent the sharply pointed drill from penetrating into the soft parts, a blunt dissector is shoved under the jaw and held tightly against it. If the drill-holes are placed after the bone has been sawn through, each end must be held firmly by the assistant by both hands, to afford the necessary resistance to the drill. If the last two molar teeth are present, they must be removed, as well as all carious stumps, as we have already said, in order not to create infection in the wound. For suture material aluminum bronze wire is employed, which may be tied like a thread. The two ends are bent down against the bone with a flat jawed forceps, and the muco-periosteal covering is carefully sewed over the wire within and without in order to prevent, so far as possible, infection of the bony wound.

Since on account of the open oral cavity the operation can never be completely aseptic, it is impossible, in spite of all precautions, to avoid occasional necrosis of the jaw or foreign body infection at the point of suture. In such cases there arise at this point, in the second week after operation, first a swelling and later a fistula, from which issues pus in limited amounts, or a scant but very foul-smelling secretion. Nevertheless, one should not remove the wire immediately upon the first appearance of necrosis, for this would interfere with the union of the bone. Only after the wounds of the soft parts have healed fast or a callus may be felt at the site of division is the wire pulled out and, if it seems necessary, the necrotic region cleaned up with rongeurs. Small sequestra not infrequently come away without further assistance in the sixth week or later, and sometimes even after several months.

Also considerable danger of infection in the loose tissue at the base of the tongue in the neighborhood of the epiglottis, and in the soft parts of the neck, arises after resection in the oral cavity,

particularly after extirpation of neoplasms on the palate and on the tongue. Accordingly the pockets in the floor of the mouth, so far as they are not covered with mucous membrane, should be packed with iodoform gauze. The end of the packing is brought out below the jaw. According to the statement of von Bergmann, the best conditions for drainage of the wound secretions are obtained by creating a fistula from the mouth opening outward in the neck. For this purpose the mucous membrane of the pharynx or of the floor of the mouth in close proximity to the epiglottis, in any case at the deepest point of the wound cavity, is seized with forceps, drawn out and united with the skin of the neck in the lower corner of the wound. Through this smooth canal opening outward at the most dependent point, secretions come away without hindrance. The end of the drain is also brought out along this canal of mucous membrane. The danger of infection of the soft parts of the neck having passed, after a certain time (about three weeks), an incision is made around the fistula, and the strip of mucous membrane is freed up and shoved back into the mouth. The wound then closes of itself by granulation tissue.

Osteoplastic resection of the lower jaw is to-day considered the regular procedure for exposing the posterior section of the oral cavity. Not only is the floor of the mouth and the palate rendered approachable by this technique, but also the posterior and lateral walls of the pharynx and the entire base of the tongue as far as the other side. One can without difficulty pull out the tongue and may undertake total removal or wedge-shaped excision from the margin as judgment dictates. With the last-mentioned operation the apex of the wedge is directed inward, in order to create as much of a new tip for the tongue as possible. If the margin is destroyed over a wide extent, one extirpates half the tongue, dividing it from the tip backward, and unites the upper margin of the wound with the wound edge on the floor of the mouth.

If the resection must be extended beyond the middle line, it is advisable to remove also the anterior mobile half. The view is less obstructed if, as should always be done in total extirpation of the tongue, bilateral ligature of the lingual artery is performed following the cleaning out of the cervical nodes.

Total removal of the tongue is best accomplished from in front. In this procedure as much of the mucous membrane from the under

surface as possible should be preserved for covering the wound. After incising and freeing up the mucous membrane, the frenulum as well as the fibrous and muscular connections with the jaw are divided step by step on the normal and diseased sides with scissors or knife, until the entire tongue can be pulled out and freed from the epiglottis and the tongue muscles. Billroth warned against completing the resection with a thermocautery in place of a knife, as the scab is not secure, and when it loosens and falls off secondary hemorrhage is possible, and infection may occur over a wide surface. If only a short section of the tongue remains, it should be covered completely with mucous membrane. On the score of safety, to prevent the tongue's dropping backward upon the entrance to the larynx, the ends of the mucous membrane sutures should be left long and made fast to the outside of the cheek with adhesive plaster.

MEDIAN DIVISION OF THE JAW

In comparison with lateral division of the jaw, the older technique of median division of the lip, jaw, and floor of mouth, originated by Roux in 1836, and the modifications by Sédilot, and more recently by Kocher, are not frequently employed. However, some recommend it as the regular procedure. According to the instructions of Kocher, the lip, and the skin covering the chin and neck, are divided in the middle line down to the level of the hyoid bone. Then, the lateral incisor having been extracted, if present, the jaw is divided through the empty alveolus a bit to the affected side of the middle line, and the two halves are drawn apart with special instruments. The insertions of the geniohyoid and the other muscles of the floor of the mouth are avoided as far as possible, but the tongue muscles are divided. Before their division, the mucous membrane in the fold between the tongue and jaw is divided on the affected side to a point far back of the tumor, but on the normal side for just a little ways, and the laterally lying nerves and vessels are exposed.

As soon as the frenulum is divided, the tongue may be pulled out on silk loops; and this is done toward the normal side. The sublingual gland, which is exposed in front, is not, as a rule, preserved; after its extirpation one proceeds along the external margin of the genioglossus and geniohyoid muscles into the depths and backward as far as the perpendicularly ascending fibers of the

hyoglossus muscle, at the inner edge of which the lingual artery and at the outer surface the hypoglossal nerve appear. Kocher now divides this muscle as well as the other muscles of the tongue, so far as necessary, with a thermocautery, and likewise the styloglossus and the affected portion of the palate and the lateral wall of the pharynx. A thin layer of zeroform powder is rubbed in on the burnt surface and the jaw sewed up with wire. Below the chin a hole is left to allow exit for the wound secretions. Then the lip is again united by suture. As the chief advantage of this technique, Kocher mentions the visibility of the mouth as far back as the pharynx, the limited resultant deformity, the advantageous conditions for carrying off the wound secretions, and the ability of the patient to swallow early.

AFTER-TREATMENT FOLLOWING RESECTION OF THE TONGUE

During the post-operative period the chief anxiety is with regard to the danger of pneumonia. In extensive resection on the floor of the mouth, this complication cannot be prevented with assurance, even if all practical precautions are taken, before, during, and after operation. Among the causes for inflammation of the lungs, septic processes in the wound, in the pockets of which the secretions stagnate, are undoubtedly of great significance. Even with the satisfactory methods of von Bergmann and Kocher for carrying off the secretions from the mouth and the wound, decomposition within the oral cavity cannot be absolutely prevented. We must consider, further, the unavoidable disturbances of the mechanism of swallowing after division of the floor of the mouth. However the pneumonia which occurs when the ability to swallow is destroyed, depends less upon swallowing, which may be rendered unnecessary by giving nourishment through a stomach-tube, than upon the aspiration of infected particles, and the direct extension of septic wound infection as the result of insufficient drainage. In order to keep the danger of pneumonia as low as possible, the muscles of the floor of the mouth should be given every consideration. For the same reason most surgeons do not employ tracheotomy.

Feeding through a stomach-tube is employed by many surgeons during the days immediately following the operation. However, this practice has so many disadvantages that it should not be employed if avoidable; on introducing the tube the wound is en-

dangered, and the patient caused what may be unnecessary pain. On the other hand it is advisable from the day after operation for the patient to accustom himself to the use of the muscles of deglutition, and he should be given fluids in small quantities so that he will not suffer in nourishment. Even after extensive division of the muscles of the floor of the mouth, patients as a rule learn to swallow properly after a few trials. If there is a fistula which opens externally, this must be closed with a pad of gauze during the first attempts at swallowing.

The after-treatment of the wound depends on whether or not it was completely covered with mucous membrane. Besides it makes considerable difference as to whether the wound surface is limited to the anterior section or whether portions of the lateral wall of the pharynx and near the epiglottis had to be removed. In the first case, the mouth can be kept clean by the use of a mouth wash, otherwise its employment cannot be considered advisable on account of the danger of aspiration on swallowing. For these cases it is preferable to keep the oral cavity clean by wiping it out several times a day with sponges which have been moistened but not saturated in a diluted hydrogen peroxide solution.

The dressing on the resection wound should be changed after a few days; even iodoform gauze, which is the best preventive for putrid decomposition, should not be left for longer than five days. If gauze must be again introduced, the end of the packing should be carried out as before at the deepest point of the external wound alongside the drainage-tube, which is also replaced. With the beginning of granulation formation upon the wound surface, the foul secretion and sloughing, as a rule, cease. Then the tube may be removed. Ordinarily, this takes two or three weeks. The canal, which opens outward, closes of itself, or after freshening; in case of necessity the mucous membrane may be stripped back and the wound edges sutured.

It is astonishing how little the speech is impaired, even in total resection of the tongue. The linguals naturally are wanting at first, but the patients learn, as a rule, to replace the lacking consonants by labials and laryngeals. The phonation is only seldom altered. In partial resection of the tongue, the enunciation ordinarily suffers only for a short time, but later in many cases it sounds hardly different than before the operation. As a rule on the floor of the mouth, as the result of the increased muscle

activity, tumorlike projections form, which may be of advantage for speech as well as for deglutition.

With this favorable procedure, one should not hesitate at the repetition of the most extensive resection, even in recurrent carcinoma. It is particularly justified if there is no recurrence in the lymph nodes. Other agents (X-rays, radium, thorium) are so insecure in deep lying carcinoma and have been subject to so little investigation that the preference must be given to rational and radical extirpation, as long as it appears practicable.

Bilateral osteoplastic resection of the upper jaw.

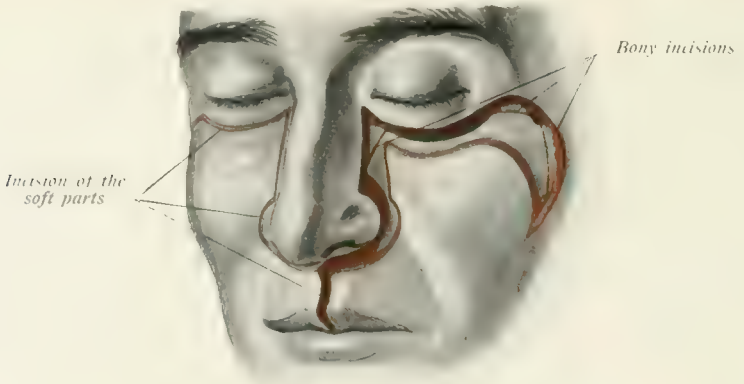


Fig. 404. Incision.

Fig. 405. Palatal incision.

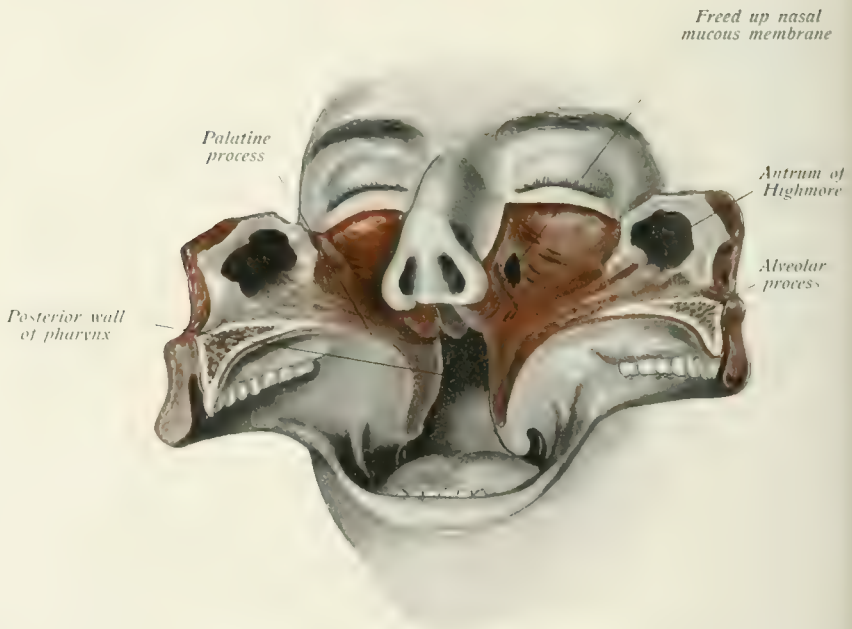


Fig. 406. Turning back the two halves of the upper jaw.

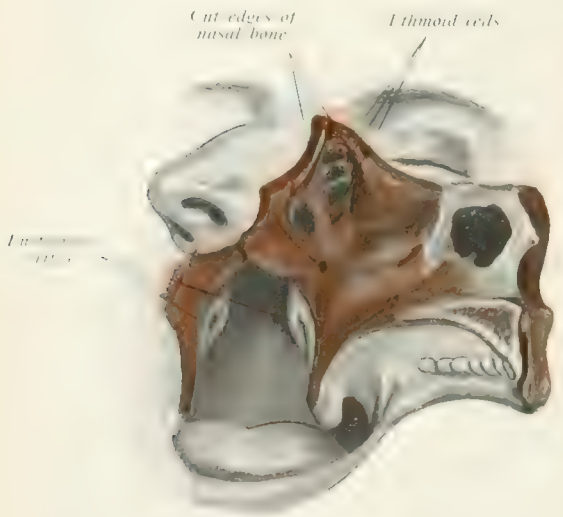


Fig. 407. The nasal bone is divided, and the nose turned back.

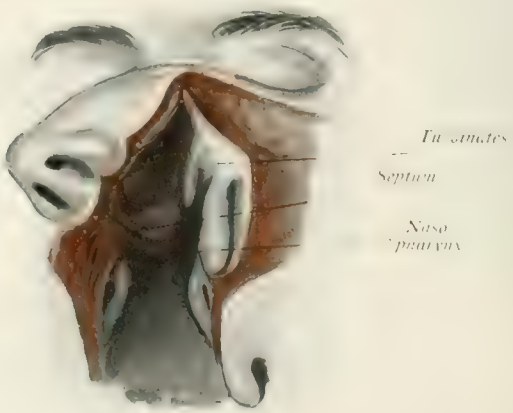


Fig. 408. Exposure of the naso-pharynx.

CHAPTER 15. — SURGICAL PROCEDURES ON THE PHARYNX

As has already been stated, with the help of the transverse incision of the cheek and osteoplastic resection of the lower jaw, not only the posterior section of the oral cavity, but also the middle portion of the pharynx is approachable for surgical intervention. Tumors of the tonsil or of the pillars which involve the oro-pharynx may, as will be shown, be satisfactorily removed under full vision by this method. The lateral and posterior walls of the pharynx may also be reached by enlarging the mouth. But the opportunity for approach allowed by these methods is insufficient for exposure of the upper or nasal section, and the lower or laryngeal section. To obtain a sufficient approach to the naso-pharynx for the radical removal of neoplasms necessitates extensive accessory incisions through the upper jaw, palate, or nose, and as wide a separation as possible of the divided bone and soft parts. But to reach the laryngo-pharynx demands accessory incisions in the neck and in the region of the hyoid bone, and lateral division of the pharyngeal muscles.

EXPOSURE OF THE NASO-PHARYNX

The widest approach to the naso-pharynx is obtained by the method devised by Langenbeck of temporary or osteoplastic resection of the upper jaw, in conjunction with upward or lateral displacement of the nose. This procedure corresponds in principle to the Dieffenbach-Weber resection of the upper jaw, which has already been described (see p. 290). The cheek flaps are not separated from the bone, but in order that they may be better nourished remain in connection with it. Bone and soft parts of both halves of the upper jaw are turned back on each side of the face (Figs. 404, 405, 406, Plate 71), and the nose, after division of the nasal bone and the bony septum, is turned upward (Fig. 407).

With the aid of this bloody and very extensive introductory

operation, one may expose the roof of the naso-pharynx, the lower aspect of the base of the skull, as well as all the neighboring cavities (Fig. 408, Plate 71), and tumors which have developed on the base of the skull or on other parts of the naso-pharynx may be completely removed. After their removal the divided upper jaw and the nose are replaced, and the soft parts of the face, the soft palate, and the mucoperiosteal covering of the hard palate are again united by suture. The divided bone does not have to be sewed. Von Bergmann states that the deformity in patients operated on by him by this method was slight. He recommends preceding the dangerous operation by tracheotomy with the tampon cannula, or ligation of one or, if necessary, both external carotid arteries. However, the hemorrhage may be controlled also by means of packing after each step of the operation.

Osteoplastic resection of both upper jaws is indicated for the removal of the typical tumors of the naso-pharynx which develop from its roof. These possess characteristic properties which make possible their diagnosis and differentiation from other new growths at the base of the skull and within the accessory sinuses with sufficient assurance.

According to von Bergmann they arise practically without exception in youth between the fourteenth and twenty-fifth year. On account of their connective tissue basis, they have a firm consistency, and they develop from the basilar portion of the occipital bone and send processes into the accessory sinuses of the nose. As they possess a tough capsule, which is also covered by the pharyngeal mucous membrane, as a rule they do not bleed, either spontaneously or on being touched with the palpating finger. Only when, as the growth extends, the mucous membrane ulcerates, profuse hemorrhage may arise, particularly on sneezing or coughing. While the fibroma at first remains limited to the naso-pharynx, later, as the result of pressure on bone and soft parts, its branches extend into the nasal cavity and the pterygo-maxillary fossa. It may spread farther, into the antrum, the orbit and through the middle lacerated foramen into the cranial cavity, and then it will present all the manifestations of an intracranial tumor.

Ordinarily the diagnosis may be made before this stage is reached. The plugging of the nasopharynx with the tumor mass may be ascertained by the rhinoscope as soon as the early catarrhal symptoms appear in the nose, or respiration, swallowing or speech are

impeded. The hard nodular surface of the tumor, covered with mucous membrane, may also be felt with the finger in the upper portion of the pharynx, and, what is of importance as regards its removal, the space between the tumor and the posterior wall. Usually the tumor may be moved slightly. In advanced cases the palate is pushed so far downward that the mouth cannot be closed, or the soft parts of the face are pushed out above and below the zygoma by the pressure of the tumor mass.

In addition to this tumor, which has a wide base, there are also observed in the nasopharynx fibrous pediculated polyps which develop from the margin of one of the choanæ; their free end, club-shaped and thickened, projects into the pharynx. Of much less frequent occurrence in this neighborhood are teratoma, submucous lipoma and other benign tumors. The occurrence of carcinoma in the nasopharynx, on the other hand, is not so infrequent. Ordinarily these tumors at first resemble the already-described typical fibroma of the nasopharynx, but when later in their growth they infiltrate bone and tissue, they may be readily differentiated from the benign fibroma. Carcinomatous tumors, as the result of retrograde changes on the surface, are inclined to bleeding and ulceration, and early metastases are usually present in the neighboring lymph nodes. Von Bergmann has also shown that rapidly growing tumors of the nasopharynx in children in the first decade, and in adults beyond the thirtieth year, are practically always sarcoma, while true fibroma is not observed in the early years, and in the later years they are stationary in growth, or they gradually become smaller. Carcinoma of the naso-pharynx, which always arises from the mucous membrane or other glandular structure, is observed still less frequently than sarcoma.

CONSERVATIVE METHODS FOR THE EXPOSURE OF THE NASO-PHARYNX

If the small size of the tumor of the naso-pharynx seems not to warrant an extensive preliminary operation, such as a temporary turning back of the superior maxilla, one can choose any of the numerous other methods recommended for opening up this region. The choice of technique depends upon the result of examination. It is of importance to determine the location and extent of the tumor, its origin and development, the width of its pedicle, and particularly whether it is benign or malignant.

For tumors which are limited to the naso-pharynx and one side of the nasal cavity, the trans-oral technique of Gussenbauer ordinarily suffices. The soft palate which is ordinarily pushed sharply outward by the new growth is split in the middle line, and the hard palate resected subperiosteally as far as the alveolar margin. Von Bergmann reports that as far back as 1870 he succeeded in removing a pediculated polyp of the naso-pharynx by simply dividing the soft palate. By resecting the hard palate, however, the view and the approach are much improved. After the extirpation is complete, packing is placed against the bed of the tumor, the end being brought out through the nose. The wound of the palate is immediately closed by careful suture just as in the operation for cleft palate; only in the presence of considerable hemorrhage, according to von Bergmann, should suture be put off until later. But even with resection of the hard palate, the approach to the naso-pharynx is still restricted.

Hoffman * recommended suprahyoid pharyngotomy according to Hacker as a preliminary operation for the removal of tumors of the naso-pharynx. The view after transverse separation of the soft parts of the neck above the hyoid is just as unrestricted as with the osteoplastic methods.

As advantages, Hoffman states the limited bleeding, the unobtrusive scar under the chin, and the conservation of the lateral muscles of the neck which are of importance in swallowing. In order to procure free approach to the base of the skull, the walls of the pharynx must be drawn wide apart, which may be done readily on account of their elasticity. If the soft palate gets in the way, it is divided in the middle line according to the method of Gussenbauer, and in the same way the hard palate may be resected, preserving the periosteal covering.

The method which allows the poorest view of all is that by which the naso-pharynx is opened from in front by temporary resection of the nasal bones, even if in addition the neighboring portions of other bones are also resected. The von Bruns method of temporary opening up of the nose is described in the section on the nasal approach to the hypophysis (see p. 194). Other methods in which only the upper region of the nose is resected osteoplastically (Linhart, Killian) allow a still more obstructed approach, and accordingly find employment only as preliminary operations for the removal of defi-

* Centralblatt f. Clin., 1907, xviii, No. 31.

nitely pediculated fibroma, for the purpose of placing a snare or a galvanocaustic loop about the base of the pedicle.

A much more visible field is offered by the osteoplastic resection of the entire alveolar process after the method of Partsch, an operation of which the technique and the advantages have already been described in the section on the exposure of both antra (see p. 185). Kocher advises the same technique, with the exception that he splits the lip and the alveolar process of the jaw together with the palatal process in the middle line, and by pulling apart the two halves, he breaks down the connections with the pterygoid process. But the employment of these two methods remains limited to the removal of such tumors as have proliferated from the naso-pharynx into the nasal cavity and the antra. But if, on the other hand, the naso-pharynx is filled with a fibroma with a broad base, which extends its nodular processes in all directions, and particularly into the pterygo-maxillary fossa, a sufficiently wide approach and a satisfactory view of the operative field is obtained only with the aid of a double osteoplastic resection of the upper jaw according to Langenbeck.

On account of the regressive properties which benign fibrous tumors of the naso-pharynx are likely to manifest at a certain age, von Bruns has advised destruction of the tumor by electrolysis, and this procedure has been carried out to advantage in several cases. The chief advantage consists in the fact that the wide accessory incisions through the bone and soft parts of the face, which are always combined with exhausting hemorrhage, are unnecessary. On the other hand, von Bergmann states that just those cases of his in which he had done an extensive operation remained well. For if portions of the fibroma remain behind in the naso-pharynx or in the accessory sinuses in the conservative operation, the danger of recurrence is excessive, and with mixed tumors containing sarcomatous tissue it is still greater. Therefore all operations through the nose or mouth, for example snaring, should be limited to polyps which are definitely pediculated.

EXPOSURE OF THE LARYNGO-PHARYNX

Malignant tumors which arise in the lower or laryngeal portion of the pharynx cannot be exposed in sufficient extent through an osteoplastic operation either on the upper jaw or on the lower jaw. Here an approach through the neck must be employed, and depending upon the situation of the tumor, the involvement of the larynx,

of the posterior wall of the pharynx, or of the base of the tongue, particular methods have been designed. As such we have to consider transverse division of the pharynx below the hyoid bone after the method of Malgaigne (transverse subhyoid pharyngotomy—see Fig. 409), lateral opening of the pharynx according to Langenbeck (lateral pharyngotomy), and finally a combination of these methods with each other or with such procedures as have been already described for extirpation of the tongue, for resection of the pillars and of the tonsils.

However, for tumors of the pharynx which are situated at the margin of the esophagus, or arise from the retrolaryngeal wall of the pharynx, neither the single nor combined methods of pharyngotomy suffice. Here, as in other portions of the lower half of the pharynx, the cases are practically without exception of a cancerous nature, and their radical removal through conservative procedures, as is shown by work of Krönlein, Lindenbron and Schumacher,* has never been attained. For a recognizable carcinoma in this part of the pharynx, as a rule, has already involved the larynx, and so extirpation of both organs is indicated. This technique has been worked up and improved by von Gluck, and more will be said on the subject in the chapter on surgery of the neck.

Lateral and transverse pharyngotomy represent methods by which new growths, particularly carcinoma of the epiglottis and the pyriform recess, as well as of the lateral and posterior walls of the pharynx, may be exposed and removed. After transverse division of the pharynx, the epiglottis may be pulled forward, displaced into the wound, and removed with the mucous membrane of the base of the tongue, of the pharynx, or of the entrance to the larynx which surrounds the new growth.

The technique of transverse subhyoid pharyngotomy is as follows: The skin incision is carried just below the hyoid from one end to the other, the head being bent sharply backward, and the lower hyoid muscles and the thyro-hyoid membrane are divided in the same direction. After freeing this membrane from the lower margin of the hyoid bone, the hyo-epiglottic ligament, which joins the epiglottis to the middle of the hyoid, is seized close to its inner margin, and divided, together with the mucous membrane of the pharynx at this place. Then if the transverse opening of the pharynx is lengthened sufficiently in both directions, the epiglottis, together with the en-

* Beitr. z. klin. Chir., 1912, Vol. 77.

trance to the larynx and the mucous membrane of the neighboring portion of the pharynx, may be drawn way out, bringing to view any tumor which is limited to these parts. The wound is closed within so far as possible by means of deeply placed mucous membrane sutures, and otherwise it is packed with iodoform gauze, the end of which is carried out through the wound.

To shut off the wound surface so far as possible from the air-

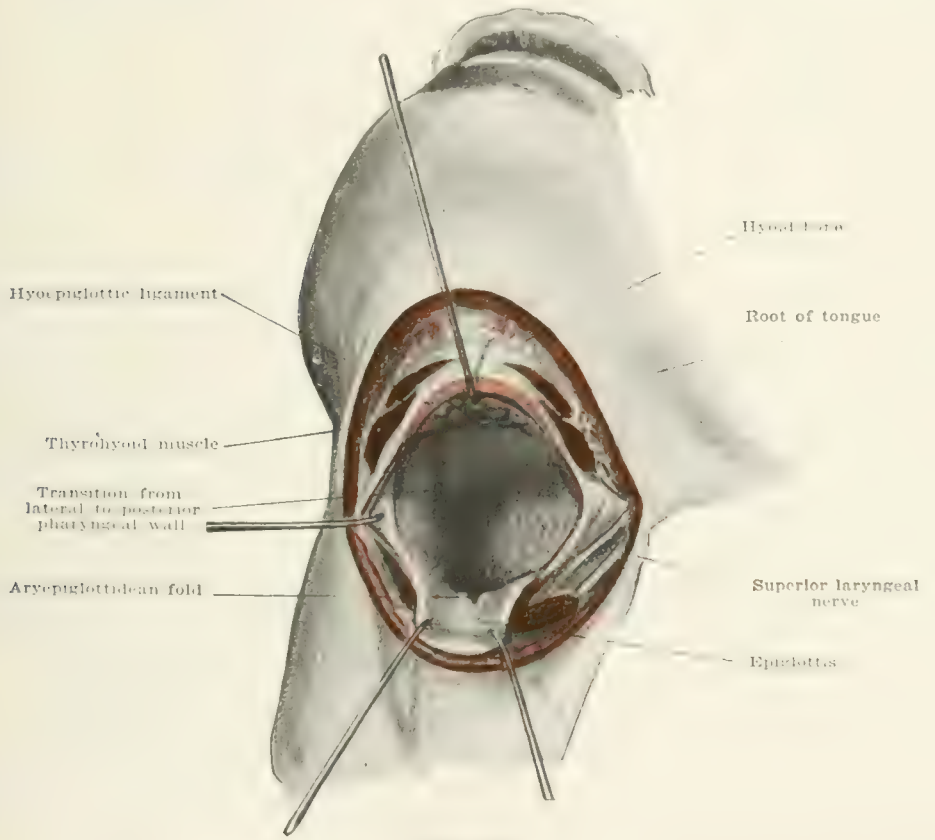


FIG. 409

Transverve subhyoid pharyngotomy.

passages is the safest means of preventing pneumonia. Large defects must be allowed to heal by granulations. The iodoform packing which rapidly becomes moistened through the mouth and the wound is changed on the third day and frequently thereafter. Finally, as soon as the danger of infection of the loose tissues of the neck, which have been exposed by the operation, and of the mediastinum, is over, the rest of the wound surface may be covered by a secondary plastic operation.

Krönlein rejects for this operation as well as for lateral pharyngotomy (see below) the prophylactic incision of the trachea, because it increases the irritation of the air-passages, and thereby the danger of pneumonia. In his patients, at any rate, pneumonia rarely appeared if tracheotomy had not been done beforehand. In order to preserve the ability to expectorate, Krönlein recommends that general anesthesia be continued only until the pharynx has been opened: the patient should be allowed to come out before this takes place. The remainder of the operation is carried on under cocainization of the mucous membrane through the mouth.

The dangers which are known to be associated with the penetration of blood into the larynx may be avoided by painstaking control of hemorrhage during the operation. Injury of the superior laryngeal nerve on one side is without significance; if bilateral, it is fraught with danger, because as the result the sensibility of the *aditus laryngis* and the cough reflex are in part paralyzed, and the danger of aspiration is markedly increased. However, one may avoid the nerve on both sides by keeping close to the hyoid bone on cutting the thyrohyoid membrane, as it penetrates this more than one cm. below the lower margin of the hyoid (Fig. 415, Plate 72). The danger of injuring the nerve just at this point of penetration is not nearly so great as that of meeting it further upward on extending the incision obliquely on either side. But even when the incision runs perpendicularly to the nerve, its division may be avoided, as will be shown in a case later on, by exposing it centrally as far as possible, lifting it on a blunt hook, and displacing it outward or upward (see Fig. 416, Plate 72).

Opinions are divided at the present time as to how a patient shall be fed after pharyngotomy. Rectal feeding does not suffice for long, particularly in these cachectic and usually emaciated patients. At the most it may be employed only as an auxiliary to other methods. The dictum of Thiersch that pharyngotomy should be preceded by a gastrostomy has not found wide acceptance; and it is also recognized that this additional operation, however slight it may seem, is not altogether without serious possibilities. The question may be solved most simply if the defect in the pharynx covers only a small area and the patient does not entirely lose the ability to swallow; in such case fluid nourishment may be taken in small quantities without difficulty, and should be given. The difficulties which at first arise in swallowing, diminish, as a rule, after a day or two.

Exposure of a retropharyngeal tuberculous lymph node.

Fig. 411. Projection below the right tonsil.

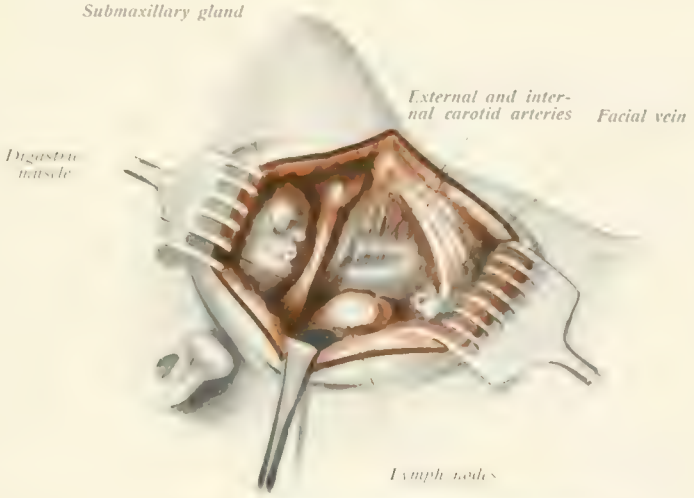


Fig. 412. Exposure of the submaxillary gland.

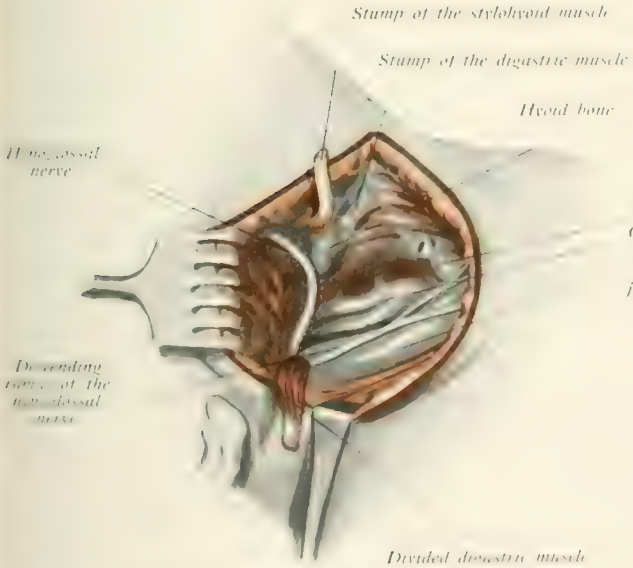


Fig. 413. Exposure of the great vessels.

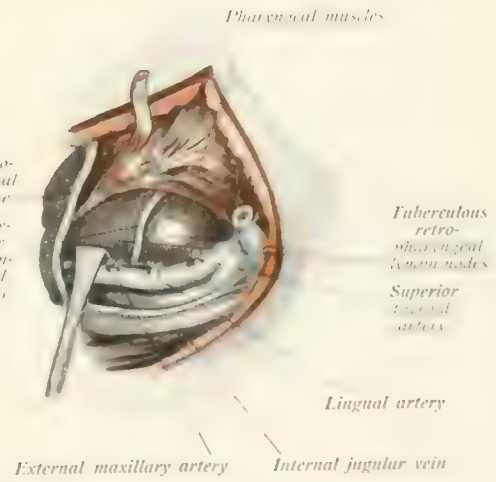


Fig. 414. Exposure of the tuberculous retropharyngeal lymph nodes.

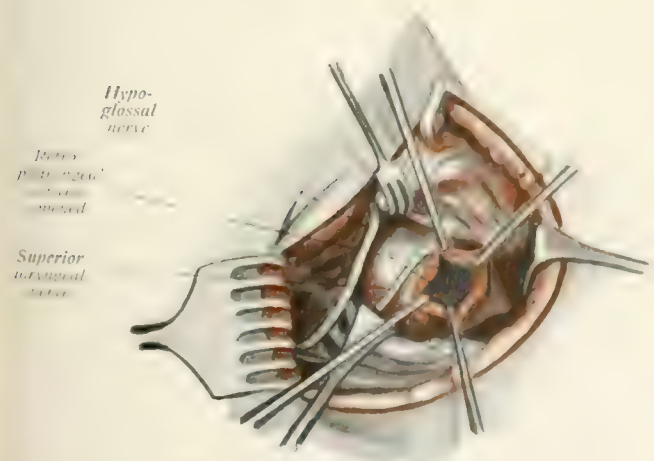


Fig. 415. The abscess opened.

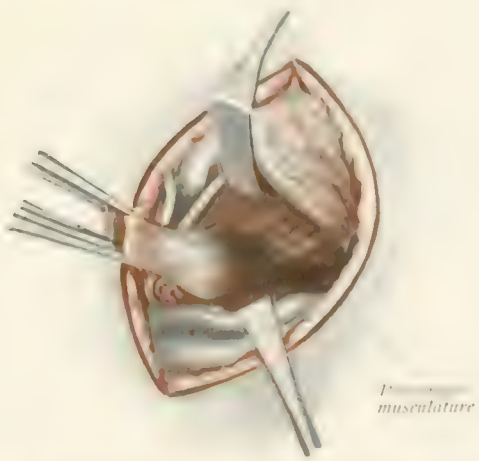


Fig. 416. The retropharyngeal abscess [illegible]

In large defects of the pharynx, particularly after transverse pharyngotomy and its modifications, the ability to swallow is at first completely lost. To feed the patient one must make use of the stomach-tube, which must remain in place or be introduced each time the patient is to be fed. However, certain dangers are associated with this technique, among which the greatest to be feared is injury of the large vessels of the neck, which in extensive resections of the lateral wall of the pharynx must, as a rule, be exposed over a wide area. Also a tube which is left in place may result in erosion of these vessels. This danger arises particularly if the wound and the thin layer of tissue which covers the vessels become infected. If the resection wound of the pharynx opens outward, the tube may be introduced through it; but this method is particularly dangerous as regards the neck vessels. In any case, it is important to employ only a soft rubber tube for artificial feeding, and to give up artificial feeding as soon as possible. The operated patients learn to swallow rapidly after careful attempts, if they are given fluids with a spoon or in small quantities in an invalid glass.

Even if the wound of the soft parts is made as extensive as possible, the room obtained by a transverse pharyngotomy is not always sufficient for the removal of a malignant tumor. To be sure, the aryepiglottidian folds and the median walls of the two pyriform recesses may be pulled out at the same time with the epiglottis, and the technique is satisfactory for tumors which are definitely limited to these sections. The side walls and the posterior walls of the pharynx are clearly visible, but they are not readily approachable for surgical procedures in the necessary extent. A further disadvantage of transverse pharyngotomy consists in the fact that the otherwise serious danger of aspiration pneumonia may be further increased as a result of the division of the epiglottis from the hyoid and the resulting disability in swallowing. The danger becomes more imminent still if blood, saliva, and wound secretions collect and decompose in the natural recesses and in the wound pockets at the entrance to the larynx caused by the resection of the pharynx.

LATERAL PHARYNGOTOMY

The original incision for lateral pharyngotomy according to Langenbeck ran downward from the middle of the margin of the lower jaw over the great cornu to the cricoid cartilage. Krönlein

modified this incision, for the purpose of widening the approach to the lower section of the pharynx, starting it near the middle line of the neck, running it outward along the lower margin of the hyoid to the greater cornu, and from there in an angle to the margin of the sterno-mastoid. According to the situation of the tumor, this incision may be lengthened upward to the mastoid process or over

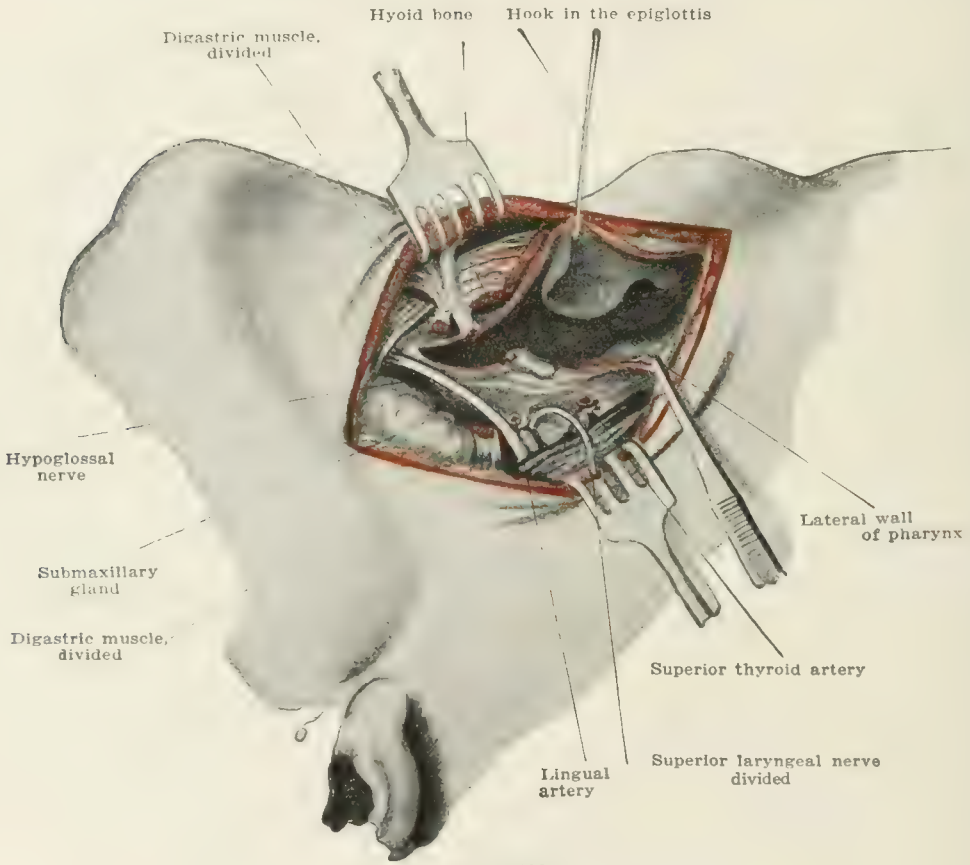


FIG. 410
Lateral pharyngotomy.

the angle of the jaw (see Fig. 417, p. 405). After division of the skin, platysma, and fascia, the omohyoid, the posterior belly of the digastric and the stylohyoid muscles are divided, as well as the transverse branches of the external carotid artery which run beneath them, the lingual and superior thyroid arteries and the large common facial vein (see Fig. 412, Plate 72). The submaxillary gland must also be removed in order to sufficiently expose the lateral wall of the pharynx.

Before the musculature and the mucous membrane of the pharynx are divided, the superior laryngeal nerve is freed up and displaced backward. If it must be cut, it is advisable, according to Küster, to tie a fine suture around each end so as to be able to reunite them after the operation has been completed. The hypoglossal nerve, which is exposed on dissecting into the depths in the upper angle of the wound, need not be injured. After this preparation and after division of the greater cornu with scissors, the pharynx may be incised on one side and opened up widely. In order to make the posterior wall and the entrance to the larynx approachable for the removal of tumors, the epiglottis may be pulled to one side and the hyoid pulled upward by sharp hooks.

The view in the middle and lower sections of the pharynx is then complete, and tumors of the pyriform recess particularly, but also tumors which arise in front and involve the lateral and posterior wall of the pharynx, may be removed with a wide margin. Foreign bodies which have been swallowed and are held so fast in the pockets near the larynx that they cannot be removed from above, may be eliminated without difficulty, after lateral opening of the pharynx and unfolding of the pockets, by a lateral displacement of the epiglottis.

As the more conservative technique and as offering the better view, this unilateral pharyngotomy deserves the preference over the transverse incision. However, at times necessity arises for modifying the typical incision, lateral as well as transverse, or for combining them in order to improve the visibility and the approach, depending upon the position of the tumor. Thus one can displace the originally described longitudinal incision from the center of the body of the jaw to the anterior margin of the sterno-mastoid, carry it down along the neck and from its center at the level of the lower margin of the hyoid make a transverse incision as far as the middle line. In this manner not only the pharynx is laid open over a wide extent, but the entrance to the larynx may also be drawn out more satisfactorily than in the above-described lateral pharyngotomy. Mikulicz and von Bergmann have combined transverse incision of the pharynx with osteoplastic resection of the lower jaw, and in this manner have removed radically cancerous tumors which have involved the lower and middle segments of the pharynx.

Finally, it should be stated that von Hacker, having in mind the unusually free approach which has been offered by the self-inflicted

incision of suicides, has originated a technique by which the pharynx is opened above the hyoid bone. This *suprahyoid pharyngotomy* possesses the advantage over the subhyoid method, in that it allows much more room in case tumors of the base of the tongue are to be removed. The laryngeal nerves and the epiglottis are not injured by the incision. After division of the mylohyoid, geniohyoid, and hyoglossus muscles, and after freeing the central tendon of the digastric from its pulley, a free approach is obtained not only to the base of the tongue, but to the entrance of the larynx and to the lateral and posterior pharyngeal walls as well.

For new growths of the pyriform sinus, of the entrance to the larynx and of the uppermost section of the esophagus at the level of the cricoid cartilage, Kocher has originated a technique which he calls *mediolateral pharyngectomy.* The skin incision runs along the lower margin of the hyoid over the entire affected side and for 3 or 4 cm. onto the normal side. In the middle line a vertical incision is made downward to the isthmus of the thyroid gland. In addition to the skin platysma and fascia, the sternohyoid, thyrohyoid, and omohyoid muscles are divided transversely on the affected side, but on the normal side the sternohyoid alone. Then the thyrohyoid membrane is divided in the middle with a "T" incision, and the epiglottis as well as the larynx is pulled out.

RETROPHARYNGEAL ABSCESS AND TUMOR

Under retropharyngeal abscesses and tumors we understand such as have their location behind the mucous membrane of the pharynx, the pharyngeal musculature and the prevertebral buccopharyngeal fascia. While tumors are only seldom met with in this stratum, abscesses are much more frequently observed. These may be divided etiologically into two large groups: to one belong tuberculous or so-called cold abscesses, and to the other the acute bacterial abscesses which arise as the result of infection of the retropharyngeal tissue through the mouth or through the naso-pharynx.

As sources of origin for tuberculous abscess we must consider the upper cervical vertebræ and the base of the skull, as well as the lymph nodes which lie back of the upper part of the pharynx; for acute infections, only the latter are to be considered. As, according to Most,* these lymph nodes are present only in early childhood, and gradually disappear after the fourth year, the occur-

* Archiv. f. Chir., Vol. 61, p. 621.

rence of an abscess arising from retropharyngeal lymph nodes is limited to the first three years of life. Only such tuberculous abscesses as arise from foci in the cervical vertebræ or in the cranial bones are observed later.

Acute retropharyngeal abscesses cause more severe symptoms, since they form within a few days, and in addition to the general toxic absorption, they give rise in a short time to local disturbances in swallowing or breathing. As a rule, these occur during the early months in children with rickets or with syphilis, or in patients with scarlet fever or measles, in whom the infection follows as a sequel to inflammatory processes within the mouth or nasal cavity. The abscess appears on the posterior wall of the pharynx as a tense projection of the mucous membrane, upon the apex of which may be seen at first a reddish discoloration which later, preparatory to the breaking through of the pus, becomes yellow. The diagnosis of acute abscess offers no difficulties, particularly if on examination with the finger fluctuation is observed.

Since any delay may result in spread of the infiltration and sudden closure of the glottis, and, moreover, as spontaneous perforation, particularly during sleep, may cause danger of suffocation on account of the sudden deluge of the larynx with pus, such an abscess should be incised early down to the lowest margin of the pocket. The operation is carried out either with the head hanging over backward or with the child in a sitting posture; in the latter case, immediately after the incision is completed the head must be bent sharply forward and held hanging down to prevent aspiration of blood and pus. In order to avoid injury, the knife is wound with a narrow sterile bandage almost to the tip, and is introduced to the posterior wall of the pharynx along the left forefinger, or better still under the guidance of vision, the tongue being sharply depressed meanwhile. If pus does not appear at once, the wound is deepened and stretched by means of a pair of blunt-pointed dissecting scissors. If the knife is reintroduced to deepen or enlarge the incision, it may penetrate into the body of the vertebra, which is still soft in children, and it has been known to break off and be left behind. It is of importance to make the examination as well as the incision rapidly, as the introduction of the finger and the depression of the tongue may, as we have observed, increase the difficulty of respiration and the cardiac weakness which are practically always present.

Tuberculous gravitation abscesses arise and grow very gradually as compared with acute abscess formation. Among the accompanying manifestations, so long as they are not opened and infected, high fever and other stormy symptoms never occur. The two forms of abscess differ also in the fact that the acute are found practically always in the middle line, while the tuberculous are more frequently to one side. The moderate bulging of the posterior pharyngeal wall at first causes no difficulties, and only when the abscess descends to the level of the entrance to the larynx or to the esophagus do disturbances of swallowing or respiration arise. However, as the abscess proceeds it is likely to work out laterally, and finding a way between the neck muscles, make its appearance under the skin of the neck in front or behind the sterno-mastoid where it is readily recognized by the fluctuation.

The diagnosis offers no difficulties, particularly if the abscess arises from a carious vertebra, for with this condition pressure on the diseased vertebra and movements of the cervical spine cause pain, and primary disease of the bone may be determined from the resistance which the patient offers to passive rotation of the head, and from the rigid posture. A lateral radiogram will confirm the diagnosis. But if no carious disease is present, the source of the abscess is likely to lie in the retropharyngeal lymph nodes, and they may be confused with cysts and with new growths of the wall of the pharynx. But it must be recognized that retropharyngeal tumors are very infrequently observed in children within the first three years, and only during this period do gravitation abscesses from tuberculous lymph nodes come under consideration, as the retropharyngeal structures disappear in later years.

The treatment of cold retropharyngeal abscess differs markedly from that of acute abscess. Opening by puncture or incision through the mouth removes the danger of suffocation which is to be regarded as the most threatening indication for quick therapeutic relief, but it exposes the abscess cavity to penetration by bacteria from the oral cavity and thus to secondary infection. For that reason, any procedure through the mucous membrane should be avoided, and incision, perhaps followed by extirpation of the entire structure, should be undertaken from without. In patients who have become greatly weakened in the presence of multiple abscesses, or in case fluctuation may be made out in the neighborhood of the mastoid or farther down on the neck, it is permissible to

remove the contents with an aspirating syringe, as is done in gravitation abscesses in other regions, and to follow this with the injection of 10 per cent. iodoform-glycerin emulsion. To prevent fistula formation and secondary infection, the needle should not be introduced directly into the point of fluctuation, but the canal of puncture should run for some distance, if possible, through normal tissue. In otherwise healthy children, if the indication for immediate relief is not present, it is advisable to expose the abscess wall and the involved lymph nodes from without, and to extirpate them.

The following observation shows how this procedure is carried on in case it cannot be determined whether the tumor on the lateral wall of the pharynx represents a tuberculous lymph node or a true neoplasm.

EXPOSURE OF A RETROPHARYNGEAL TUBERCULOUS LYMPH NODE

A mother brought a child under three years of age to the hospital for admission, with the history that for weeks it had slept with the mouth open, and finally developed an obstruction to inspiration. In the last fortnight the difficulty in swallowing had increased and the nutrition had suffered. At the present time the child could take fluids only with great effort.

On examination of the otherwise strong and healthy child, there was found, in addition to the hypertrophy of the tonsils and adenoids, a projection about half as large as the end of the thumb in the lower section of the pharynx (Fig. 319). This extended downward to the level of the entrance to the larynx and upward to the lower margin of the right tonsil, and it was fairly firm to the touch. Fluctuation could not be definitely made out; the pharyngeal mucous membrane could be moved freely over it, and it showed no inflammatory reddening. Externally no thickening could be felt in the neck, even on bimanual examination.

It was noticed that at first, after entrance to the hospital, the respiratory and deglutition symptoms improved under the influence of local applications to the pharynx and cold dressings to the neck, while the swelling maintained its extent and its firm consistency. As the diagnosis was rather obscure, although retropharyngeal abscess was first to be thought of, a diagnostic puncture was performed, and X-rays of the cervical spine were taken, both without result.

Satisfied with the temporary improvement and because of their

dislike of operation, the parents took the child home again, but they brought her back a month later on account of marked stenosis. The condition had changed but little, but at this time, however, there was a slight swelling to be felt externally in the neck below the upper section of the sterno-mastoid and behind the ramus of the jaw. The tumor on the pharyngeal wall had spread somewhat toward the middle line, but it still possessed a firm consistency. The danger of suffocation being imminent, operation was undertaken at once in the following manner:

Prophylactic tracheotomy or intubation according to the method of Kuhn were unnecessary, as the air-passages could be opened from without in case of necessity, and with careful tying of the vessels blood could not penetrate unseen into the larynx and be aspirated. On account of the air hunger, and the variable and often very marked filling of the veins of the face and neck, the danger of air aspiration seemed more to be feared; in order to meet this danger the veins were all double tied and divided as soon as they were met.

The incision began similar to that for the lateral pharyngotomy of Krönlein (Fig. 417), at the lower margin of the mastoid process, and was carried down along the anterior margin of the sterno-mastoid over the tumor, turned toward the middle line at the level of the hyoid, ran forward along its lower margin, and ended at the middle line. The skin, then the platysma, which in this child was already well developed, and finally the superficial fascia of the neck were divided. After the wound edges were drawn apart, the large common facial vein and several of its smaller branches, particularly those for the submaxillary gland, could be isolated in the loose connective tissue of this region by blunt dissection, double tied and divided (Fig. 412, Plate 72). At the upper margin of the wound were exposed the submaxillary gland, the digastric and stylohyoid muscles, as well as the hyoid bone, and in the posterior angle a hard lymph node the size of a cherry lying upon the internal jugular vein. In the depths of the wound the two carotids could be seen through the thin common sheath. They were evidently displaced forward and outward as the result of the retropharyngeal growth.

In order to reach the primary focus of the disease the submaxillary gland was removed, the digastric and the stylohyoid muscles divided, and the lymph nodes situated behind on the large

veins removed. The submaxillary gland was dissected out in typical fashion (see Plate 73, p. 422), and with this intent was freed up from the substrata along its lower margin and turned up, whereupon the facial vein below and the facial artery along its upper border had to be double tied and divided. In turning up the gland, which now appeared enlarged and discolored, it was freed also in the regular fashion from the veins which entered it from below. Then, on exerting traction, its duct and the lingual nerve came into view. After tying the duct of Wharton in the muscles of the

FIG. 417

Incision for lateral pharyngotomy (Krönlein) and for exposure of the retropharyngeal lymph nodes.

floor of the mouth, it was divided near this ligature and the gland removed.

Hereupon, in the bottom of the submaxillary pouch the curving portion of the hypoglossal nerve lay completely exposed, and, lying upon the vessels of the neck, its descending branch (Fig. 413, Plate 72). In order to reach the tumor, the hypoglossal nerve had to be displaced upward and the carotids backward and downward. In the attempt to accomplish this, the branches leaving the carotid at this level were put under tension, and in order to reach the space behind the pharyngeal musculature it became necessary to double tie and divide them, namely the superior thyroid, the lingual and the facial arteries. Only after these were tied and the musculature of the pharynx pushed forward was it possible to define a hard tumor about the size of a chestnut, over the middle of which ran the superior laryngeal nerve (Fig. 414, Plate 72).

The external wall, as could be determined from without, consisted of tough, indurated connective tissue. But the size of this tumor, which extended below to the level of the cricoid cartilage, was too great for a simple enucleation, even with the hyoid bone drawn away from the operative field with a retractor and the superior laryngeal nerve displaced forward. Nothing remained to be done other than to incise the capsule where fluctuation was now demonstrable, and to allow the fluid to run out, after protecting the surrounding tissue by gauze packing. Accordingly, the wall was incised rather low down and the wound edges held apart with hemostats (Fig. 415, Plate 72).

Immediately upon incision of the wall, which was several millimeters thick, about a teaspoonful of yellow, tenacious pus emptied itself; the entire formation was evidently of tuberculous origin and the capsule represented a layer formed of the cortex of the gland and of connective tissue. Emptying sufficed to allow the capsule to sink in slightly at the lower pole; the little finger was introduced and it was determined that it was filled within by soft granulations; accordingly, all the affected tissue was removed with a curette. Hemorrhage ceased when the sac was packed tight for a short time with iodoform gauze. After removal of the packing it was found with the little finger that the now smooth wall of the cavity extended backward in front of the cervical spine. But nowhere could rough spots or soft places be felt on the vertebræ.

Although the capsule collapsed after cleaning out the granulations, the attempt to remove it entire had to be given up on account of the danger of injuring the posterior wall of the pharynx. For one could very clearly feel, above and in front, the mucous membrane of the pharynx covering the wall of the cavity as a very thin layer. But below, just where the pharyngeal musculature was united with the capsule and externally near the neck vessels (Fig. 416, Plate 72), the sac could be freed up from the surrounding tissue without difficulty, and as much as could be drawn out was cut away. What remained behind were once more curetted and a short piece of iodoform tape introduced. Then the protective packing was removed, the laryngeal and hypoglossal nerves replaced, and, to better protect the cervical vessels, the fascia and skin were closed up to the point of exit of the drain, but the cut ends of the digastric and stylohyoid muscles were not united.

Healing occurred without incident. On the fifth day the drain

was removed, and about .5 c.c. of a 10 per cent. iodoform glycerin emulsion injected, and the small hole in the skin was closed with two sutures.

On the evening of the day of operation the small patient breathed entirely without difficulty, and from the next day on she drank milk and other fluids. Very soon she could take solid nourishment also. No fistula resulted. The enlarged tonsils were removed a few weeks after the operation.

Six months later only the linear scar below and behind the right side of the lower jaw was visible. From within the mouth no difference could be recognized between the right and left halves of the pharynx. The child was able, as the mother stated, to breathe perfectly freely and to swallow without difficulty.

RETROPHARYNGEAL TUMORS

True neoplasms situated behind the mucous membrane of the pharynx, which are observed rather more frequently in the later years of life, practically all, whether benign or malignant, belong to the group of connective tissue tumors. Thus fibromata, dermoids, lymphomata, and the sarcomata which develop in connection with the prevertebral fascia, have been described.

In the retromucous tissue of the pharynx in the neighborhood of the pillars, *mixed tumors,* composed of fibrous and epithelial elements, sometimes develop, which may reach a considerable size without causing symptoms. For the most part they arise from the parotid gland, and they maintain their connection with the mother tissue through a pedicle. It is remarkable that for some years, in spite of their size, they maintain their benign nature, but later they change and assume the same properties as a sarcoma or carcinoma. At first they lie in a loose connective tissue capsule; they are movable under the mucous membrane and may be readily shelled out. This may be done in small tumors after incision of their mucous membrane covering through the mouth; in case of necessity, accessory incisions may have to be made through the cheek or the soft palate. But as soon as they change their nature and become adherent to the tissues of the neighborhood, extirpation must be done from without. This also is ordinarily accomplished without difficulty; but the pharyngeal mucosa must be sacrificed so far as it is inseparable from the surface of the tumor, or, in common with it, has undergone ulceration.

Retropharyngeal neoplasms are usually situated in the oro-pharynx, less frequently in the naso-pharynx, and still less frequently in the laryngo-pharynx. Among the benign tumors which arise in these localities, a *retrovisceral goiter* is to be considered one of the most important, for, in addition to mechanical disturbances in breathing and pain on swallowing, it may also cause paralysis of the recurrent laryngeal nerve. The danger of suffocation is increased if inflammation occurs, and to this the displaced portion of the thyroid, as the result of the readily wounded surface projecting into the pharynx and covered with mucous membrane, is particularly liable. Extirpation is undertaken from without and the tumor, and the connections with the lateral process of the thyroid which are usually present, is rendered approachable by the aid of the technique described for retropharyngeal lymph nodes. Fibrous tumors of the oro-pharynx may be extirpated with the best exposure after temporary lateral division of the lower jaw, as Krause has shown.*

EXTIRPATION OF THE PHARYNGEAL TONSIL

The lymphoid tissue which lies within the mucous membrane at the fornix of the pharynx and which forms the basis of the pharyngeal tonsil is always present in children, but it usually disappears later, beginning with the twentieth year. If it becomes inflamed, soft, spongy, and easily bleeding proliferations may be felt with the finger behind the soft palate. Under the name of *adenoid vegetations* of the naso-pharynx, they may there tumorlike completely block the posterior nasal orifice and the openings of the Eustachian tubes, so that affected children breathe with the mouth open, talk with a nasal twang, suffer from pains in the neck and ears, as well as headache, and at times also from asthmatic conditions, and may even be retarded in their mental development. From the dental aspect, it has been demonstrated that the development of the upper jaw and of the permanent teeth is likely to be interfered with by hypertrophied adenoids and the secondary disturbances.

Ordinarily the disease may be recognized at once on observation by the rather simple expression and the puffiness of the face, but since inflammatory changes and anomalies of the turbinates, septum and Eustachian tubes may result in similar manifestations, mistakes are possible. Digital examination, or still better visual exam-

* Verhand. d. Deuts. Gesells. f. Chir., 1890, p. 127.

ination of the naso-pharynx by means of anterior and posterior rhinoscopy, will confirm the diagnosis in doubtful cases. Hypertrophy of the adenoids is observed most frequently in children from the sixth to the twelfth year, and in adults only if the tissue which was diseased in childhood has not retrogressed after puberty. The true cause for this hypertrophy which is so frequently met with is not known; it develops frequently in strong and otherwise completely healthy children. It has nothing to do with tuberculosis.

Treatment of hypertrophied pharyngeal tonsils consists in their removal from the posterior wall of the pharynx. In children, removal is indicated particularly as a means of preventing undesirable sequelæ in the ear, nose, and jaw, and in adults, as soon as the less extensive therapeutic measures, such as cauterization through the lower meatus or internal medication, prove unsuccessful. In order to carry out the erasion, a technique was formerly employed which was advantageous on account of its completeness, but which is now seldom made use of. It consisted in the introduction of a middle-sized Volkmann curette into the lower meatus, with which, under the guidance of the left index finger introduced through the mouth behind the soft palate, all the proliferated tissue was removed from the posterior wall of the pharynx. If the curette was drawn not only from above downward, but a few strokes were also made from right to left, it was hardly possible for any of the proliferated tissue to remain behind. The advantage of the method, apart from the completeness with which the lymphatic tissue could be removed, lay in the fact that injury was impossible if the curette was employed entirely in the naso-pharynx. The operation was carried out under semi-anesthesia; the patient could not be completely anesthetized, as he might aspirate blood or portions of tissue. The hemorrhage, which at first was severe, soon ceased of itself; otherwise it could be controlled in a short time by packing the naso-pharynx tightly through the lower meatus and by compressing it with the fingers from below.

Nowadays the removal of adenoids is ordinarily undertaken through the mouth. The instrument of Gottstein, a ring-knife set at right angles to a long handle, or one of its numerous modifications, has proved of great practical value. In carrying out the operation the tongue is depressed, and the instrument, with the handle elevated, is introduced behind the uvula into the naso-pharynx under the direction of the eye, to prevent the soft palate

from getting caught in the ring and later being cut (Fig. 418). The handle is then depressed and drawn slightly forward, whereupon the ring slides up behind the posterior nasal orifice. If this

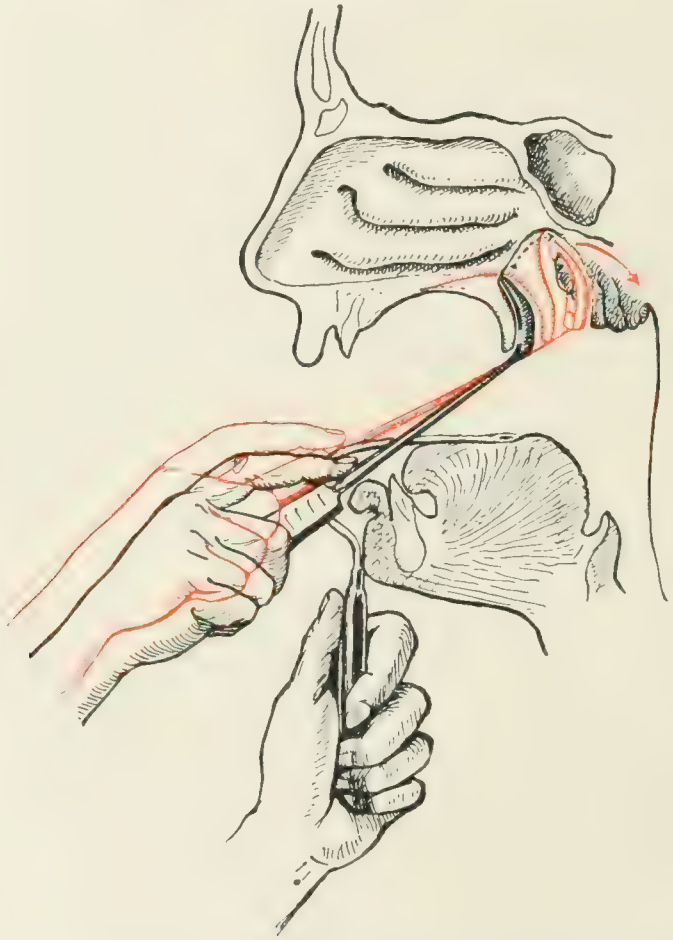


FIG. 418

Schematic representation of adenectomy.*

The black lines show how the soft palate is drawn forward by the adenotome introduced behind it; the red lines show the instrument being carried along in the direction of the arrow.

is accomplished without hindrance, the knife is shoved hard along the roof of the pharynx, and then shaves the posterior wall of the naso-pharynx by a few strong strokes from above downward in the middle line and to either side. Finally, in order to remove the last tabs of tissue a few transverse strokes are made from right to left, with the knife at an angle of forty-five degrees, to clear out the

*From Bruck, Diseases of the Nose and Throat, Rebman Company, New York.

fossæ of Rosenmüller. One succeeds either in removing the tonsil entire, as can sometimes be determined later by looking it over, or it comes out piecemeal. In the latter case it is necessary to examine the pharynx again for remaining portions of tissue.

At first the hemorrhage is considerable, but it stops ordinarily as soon as the patient ceases to cough and retch and once more breathes quietly. However, secondary hemorrhage after a few hours, or even after days, is not unusual, particularly if a portion of the tonsillar tissue has been left behind. If the cause does not lie in the fact that a neoplasm has been curetted by mistake, the secondary hemorrhage can be controlled more assuredly by curetting the wall of the pharynx again, or by packing with the Bellocque cannula. Another unpleasant circumstance during adenectomy consists in the separated adenoid remaining behind or being swallowed. Even if the latter does no harm, nevertheless the control over a really complete removal is wanting. If the loosened tissue cannot be pulled out with the finger behind the soft palate, a common method which helps in children is to hold the mouth tightly closed with the hand. As a result they are forced to breathe in strongly through the nose, and the tonsil falls without further trouble into the pharynx; however, as a rule it is swallowed. To prevent these possibilities there has been devised an adenotome which carries a small basket with two prongs which catch and hold the separated tissue, and which is convenient to use in young children.

Anesthesia is not necessary in infants, but it is ordinarily employed in children beyond infancy, and it is advisable that the operation be combined with a tonsillectomy, as is frequently the case. The operation cannot easily be done without anesthesia in adults. As in all procedures in the range of minor surgery, the ethyl chlorid rausch gives a temporary but fully sufficient anesthesia, and can be used for this purpose also in children. The operation may be carried out under local anesthesia with assurance: anesthesia of the mucous membrane of the posterior part of the nose, of the palate and pharynx, is obtained by painting these regions with 10 per cent. cocain solution, to which a few drops of suprarenin have been added. Then the base of the adenoids is anesthetized as much as possible at the upper and lower poles by the injection of a half per cent. novocain-suprarenin solution. This injection is carried out through the lower meatus, simply using a long needle, or, to avoid danger of damage from the sharp point, a cannula of sufficient

diameter with a blunt end is first introduced as far as the posterior pharyngeal wall, and through this a fine injection needle is passed. In order to reach the upper wall of the pharynx, one can use a cannula and needle which have a slight curve.

If recurrences occur in spite of complete removal, particularly in scrofulous children, the operation must be repeated.

After-treatment consists of rest in bed for several days and the administration of ice pills and cold fluids or ice cream. The catarrh which commonly follows removal of adenoids must be carefully looked out for. A foul taste, which occurs as the result of decomposition of the wound secretions, may be overcome by douching the mouth and nose with dilute hydrogen peroxide.

CHAPTER 16 — SURGICAL PROCEDURES ON THE SALIVARY GLANDS: INJURY OF THE SALIVARY GLANDS

Of the two large salivary glands, the superficially situated parotid is more open to external injury than the submaxillary, which lies protected by the jaw-bone. Incised and lacerated wounds of the cheek not infrequently involve the gland, which is situated in front of the ear and covered only by the skin of the cheek or its duct, and brings about a considerable hemorrhage from the vascular tissue or causes a salivary fistula. Moreover the facial nerve, which is deeply imbedded in the glandular tissue, may be injured by penetrating wounds. Bleeding from the parotid may be controlled by simply tying the single vessels, by suture of the wound surfaces, or, in infected wounds, by packing with gauze. Hemorrhage from the submaxillary gland is more difficult to control, as it is kept up by the facial artery, which runs a tortuous course in the capsule of the gland, and by numerous veins. To bring it to a stop not infrequently the gland has to be extirpated, or at least the facial artery tied at a point proximal to its entrance into the capsule.

Greater difficulties than those of hemorrhage are offered by the repair of the *salivary fistula*, which practically always arises after injuries of the parotid of any extent. From the point of view of cure, it is of great significance whether it is a small glandular fistula which results from injury of the parenchyma, or whether the duct is injured and it is accordingly a case of duct fistula. It is also of importance to know whether the cheek has been cut only down to the mucous membrane or whether this also has been divided; in the latter case, there occurs an internal fistula opening into the oral cavity, and in incomplete division of the cheek an external fistula. This differentiation is of some importance as regards prognosis, for the external fistulæ not only cause troublesome symptoms, but they show no particular disposition to heal. However, if an internal fistula is formed at the time of injury, from the beginning practically all the saliva flows into the mouth, and the external wound can heal up just so much quicker.

If the parenchyma alone is injured, as may occur after cuts or

operative procedures on the cheek, on the lower jaw, or on the third division of the trifacial, the secretion of saliva ordinarily dries up in a short time without particular surgical assistance. But so long as unclean ligatures or other infected material remain behind in the depths of the wound the fistula shows no disposition to heal. Only after these things are cast off and the wound has cleaned itself does the flow of saliva let up, and finally discontinue altogether.

On the other hand external fistulæ of the duct heal of themselves with difficulty. After a lesion of the duct of Steno, saliva is secreted in large quantity, particularly when the gland is excited to stronger secretion by taking of food or on talking. The external wound in the cheek may heal in injury of the duct, leaving an opening the size of the head of a pin; but just below the scar a large pocket remains, particularly in fistulæ of long standing, which gradually lines itself with a sort of epithelium from the injured duct or from the skin, or if the fistula is internal, from the mucous membrane of the mouth. Within this pocket the peripheral stump of the injured duct, as a rule, gradually retracts, glues together, or becomes obliterated, so that every attempt to find and to probe this natural opening in the mucous membrane of the mouth is unsuccessful. If on therapeutic grounds one opens this subcutaneous pocket filled with saliva, it is impossible even to find the opening of the proximal stump, particularly in old fistulæ. However, if one succeeds in introducing a hair-sized probe through the natural orifice of the duct of Steno, even fistulæ of the duct may at times be made to heal without surgical intervention; but months are necessary.

The basis for the difficulty in healing in such cases ordinarily lies in the fact that granulations or swelling are present in the neighborhood of the injury as the result of deep-lying foci of infection, and mechanically block the peripheral opening. Less frequently the cause for the delay in spontaneous healing must be sought in the fact that the peripheral segment has been covered and closed by a flap of skin or mucous membrane. Spontaneous healing of the fistula is to be considered impossible only if the peripheral portion of the duct of Steno has completely necrosed and disappeared or has become obliterated, for instance by new growths or ulcerative processes in the cheek.

The simplest procedure for inducing healing of an external

fistula, even in cases of long standing, consists in freshening the wound edges and uniting the divided tissue by suture. The attempt to unite the cut ends of the duct directly by suture is usually without result. For even if the two stumps are visible, the suture does not succeed on account of the small lumen. In addition to its technical difficulty, the attempt usually miscarries because neither the central nor peripheral end can be found. It is also useless in most cases to attempt to pass a probe through the peripheral stump from the oral cavity, because after injury and draining off the saliva, the orifice of the duct in the oral cavity is likely to shrink and cannot be found.

The result, however, which excision of the margins of the fistula together with the scarred and granulating wound surface may offer for the re-establishment of the proper path, may be demonstrated in a fistula of over three months' duration, which resulted from a saber cut. The attempt to expose the ends of the divided duct at the margin of the masseter from without in order to introduce a very fine probe did not succeed. In spite of this, immediately after the operation the saliva found its proper means of exit.

In order to expose the duct of Steno in similar cases, the cheek must be divided a finger's breadth below and parallel to the zygoma. The duct runs just behind the masseter muscle, turns medially at its anterior margin downward and into the depths, and then lies at the level of the lower margin of the upper teeth between the buccinator muscle and the mucous membrane of the cheek, which it penetrates a few centimeters from the corner of the mouth, opposite the second molar tooth.

If, following extirpation of new growths, necrosis after infectious processes, or injury, so large a portion of the duct is destroyed that spontaneous union of the two stumps appears impossible, the external fistula must be removed operatively. In all the methods which have been originated so far no attempt is made to seek the peripheral end: the flow of saliva is conducted into the mouth from the central stump by a shorter route. The wound or scar is freshened round about, and the oral mucous membrane is exposed from without over an area at least the size of a half dollar, without at first being opened. In the external wound a funnel of oral mucous membrane is pulled outward by means of forceps. It is opened at its apex, and this opening is sutured to the area around the freed up central end of the duct.

This procedure can be carried out only if the oral mucous membrane is readily movable and has not suffered from scar contraction. In such cases, according to Nicoladoni, a tongue-shaped flap is dissected up from the mucous membrane at some distance, the base lying toward the ear under the masseter and an apex which can be turned over the anterior margin of the masseter as far as the central end of the duct on the skin of the cheek. From the tongue-shaped end of the mucous membrane, a sort of tube is formed by suture of the free edges and it is united by suture to tissue about the orifice of the central stump. The defect in the mucous membrane of the cheek is closed by immediate suture.

Upon the observation that external fistulæ heal as soon as an internal one is formed depend the methods of Kaufmann and Deguise. According to the method of Kaufmann, in the base of the wound cavity a hole is punched obliquely into the mouth with a trocar having a diameter of about four millimeters, and a small drainage-tube is passed through the new canal into the oral cavity. The tube is allowed to remain a fortnight until, through epithelialization of the lining, a permanent fistula has been formed. Küttner has remarked that this new wound canal should not penetrate the fibers of the masseter muscle, as pain and contracture of the jaw are readily induced.

According to the procedure of Deguise, the external margin of the fistula is surrounded by an incision and the wound deepened until the mucous membrane of the duct has been exposed, or if this cannot be found, the oral mucous membrane. About one cm. of this is enclosed by a loop of wire, the ends of which are tied tightly in a knot within the mouth. At first, to be sure, the larger part of the saliva continues to run outward as before, and only a portion is carried along the wire into the oral cavity. If the knot is twisted a little tighter each day with forceps, the portion of the mucous membrane which it encompasses dies. In this way a wide communication is gradually established between the pocket filled with saliva under the skin of the cheek and the oral cavity, which is likely to line itself with epithelium from the remains of the divided duct, or from the oral mucous membrane. As soon as the internal fistula is formed, the external wound can be closed by suture.

It is rare that on account of a stubborn external salivary fistula it becomes necessary to extirpate the entire parotid gland; with

this operation injury of one or another branch of the facial nerve can hardly be avoided. But in cases in which the facial nerve has already been destroyed by injury or a new growth, and restoration of its function seems impossible even after healing of the external fistula, the gland may be completely removed or at least destroyed.

Extirpation of the parotid is carried out through an incision which runs obliquely in front of the ear, beginning at the zygoma and ending on the sterno-mastoid muscle below the angle of the jaw. After retraction of the wound edges, the gland is freed up from its bed by blunt dissection. This can be started most easily on the surface which lies upon the masseter. If necessary, a transverse incision must also be made. More difficulty is offered by the extirpation of the portion of the gland which lies behind the jaw in the retromandibular fossa. Here it is particularly the close union of the vessels of the neck with the capsule which makes blunt dissection difficult. Accordingly the upper branches of the external carotid must usually be tied, and sometimes the artery itself, as well as the large veins of the face. Finally, the portion of the capsule which lies toward the styloid process is shelled out, which ordinarily demands ligation of the facial artery in the depths.

INFLAMMATORY DISEASE OF THE SALIVARY GLANDS: PAROTITIS

Of the acute inflammatory diseases of the parotid gland, the primary epidemic or endemic infections are of less surgical significance than the secondary parotitides which result from infectious or other diseases. The first class ordinarily resolve without complication, but it is infrequent that secondary infections subside without abscess formation or necrosis of the gland. Since pus is held back by the tough parotido-masseteric fascia and its way to the surface impeded, danger arises lest it proceed along the vessels or along the deep processes of the gland as far as the cranial cavity, even to penetrating the dura. Early incision of the broken down section of the gland is accordingly necessary in order to prevent further infiltration by the pus.

There are two methods by which secondary parotitis may arise: bacteria may be brought in the blood stream or they may find their way up through the salivary duct from the oral cavity. While true pyemic disease of the parotid does not differ from the metastatic abscess in other parts of the body, infection of the gland

from the mouth is dependent upon pathological changes in the oral mucous membrane or upon disturbances in secretion of saliva or mucus. This type of parotitis may arise after any infectious disease associated with fever, particularly typhoid, infectious diarrhea and other febrile infectious diseases which are accompanied by stomatitis.

Secondary infectious parotitis is feared as a dangerous complication after operative procedures, particularly after celiotomy. Formerly it was a frequent complication after ovariotomy, and later, when operations upon the stomach and intestines became more numerous, just as often after these procedures. Septic disease within the abdomen particularly predisposes to post-operative parotitis, for instance septic cholecystitis and gangrenous incarcerated hernia. Among apparently clean cases, secondary infection of the salivary glands is not infrequently observed after resection of the colon for carcinoma, or after operation for ulcer of the stomach or of the small intestine.

But even after celiotomies which clinically run an aseptic course, infection of the glands is observed, particularly in patients who are starved or have been maintained for a considerable time upon rectal feeding, in whom the secretion of saliva in the oral cavity has had an opportunity to dry up. For this reason most authors maintain that the disease arises through the oral cavity, while Fränkel, on the other hand, considers the hematogenous origin as the usual one. In order to excite the secretion of saliva early, Fenwick* advises that the patient be given gum to chew. It is better not to let the patient go hungry and thirsty before the operation unless absolutely necessary, and in any case to keep the mouth from getting dry by mouth washes, by allowing fluids in small quantities, or by subcutaneous salt solution.

Ordinarily post-operative inflammation of the salivary glands arises from the fourth to the eleventh day after the surgical procedure. Usually one side alone is involved, but sometimes the affection is bilateral. At first there is only a slight swelling of the affected cheek, but this is usually from the first accompanied by acute pain, which is transmitted down the neck or to the ear. While in a mild infection, such as rarely occurs after operation, the parotid gland remains or persists in this condition of swelling for a time and then goes down again, in most cases the gland

* British Medical Journal, May 29, 1909.

soon begins to break down with high fever and manifestations of severe sepsis. Fluctuation is not readily demonstrable on account of the tension of the parotido-masseteric fascia. But abscess formation is practically never in doubt on account of the pulse and temperature curves and the accompanying symptoms. Even if the focus is incised early, post-operative parotitis is always a complication of bad import, especially as the danger is increased by the original disease.

In incising the infiltrated section of the cheek, particular care should be taken with regard to the facial nerve. This, after it has entered the retromandibular portion of the parotid, runs within the glandular substance, and at the level of the junction of the lobule of the ear with the cheek it divides into numerous branches which distribute to the mouth and lids. The division takes place just in front of the anterior margin of the auditory meatus. From this point the branches radiate through the gland and come to the surface upon the parotido-masseteric fascia. In order to safely avoid injury of the facial nerve, incision is made over the region of greatest swelling or of fluctuation, the fascia is divided with the knife, and the pus pocket is opened by blunt dissection with the knife handle or with closed dissecting scissors. The branches of the facial nerve are easily separated with a blunt instrument. Ordinarily as soon as the fascia is divided turbid fluid appears, and if necrosis has not yet taken place, the relief of tension suffices to limit the formation of pus.

But if the necrosis has advanced, transverse incision of the cheek is insufficient even if it has been lengthened backward as far as the anterior margin of the sterno-mastoid. In addition to the transverse incision, another must be made running down along the anterior margin of the muscle. After incision of the fascia, not only must the retromandibular portions of the parotid be reached and foci of pus opened with the dissecting scissors, but also any other foci of pus which have burrowed down into the neck after perforation of the capsule of the parotid must be similarly evacuated. If one succeeds in overcoming the infection by incision, healing occurs in a few weeks if the drainage is adequate, after necrotic portions of the fascia or of the gland itself have been cast off. Paralysis of the facial nerve, which arises occasionally as the result of inflammatory swelling of the gland, disappears after a considerable time, while that which arises from injuries

or necrosis of the nerves remains permanently. In the same way, the external secretion of pus ceases of itself if granulations form and the wound heals over satisfactorily.

Acute inflammatory diseases of the submaxillary gland occur less frequently than those of the parotid, particularly post-operative and metastatic abscesses. On the other hand secondary infection of the submaxillary gland is to be feared as one of the most serious affections of the jaw. This cellulitis, known under the name of Ludwig's angina, does not, as a rule, limit itself to the gland, but it spreads from the muscle pocket in which it lies to the loose connective tissue of the floor of the mouth and the deep layers of the neck, while the pus has difficulty in finding its way to the surface on account of the tense external fascia. The treatment of this condition has already been considered (see p. 348).

Less frequently observed than acute inflammation of the submaxillary gland is isolated disease of the sublingual gland. The infection, practically without exception, arises from the submaxillary gland, with which the sublingual gland is in connection.

Chronic inflammatory disease of one or all of the salivary glands only exceptionally requires surgical interference; but occasionally, in the form of symmetrical disease of the lachrymal and salivary glands described by von Mikulicz, one or more of the most swollen glands are extirpated. Shelling out of one submaxillary gland may also be indicated in any tumor-like chronic swelling of the gland, if differentiation from a real new growth is not certain or is impossible. Küttner first recognized these inflammatory tumors of the submaxillary gland and described them as of tough formation, the size of a hen's egg, arising from hyperplasia of the fibrous elements of the gland. Partial resection or total removal of one of the affected glands may be required also in fistula formation after tuberculous, actinomycotic, or luetic disease, if internal medication or the curette gives no result.

SALIVARY CALCULI

In the ducts of the large salivary glands concretions of calcium phosphate or carbonate form at times. There may be a single stone present or there may be several, and they may be situated even as far back as the finest ducts. The submaxillary gland is more frequently affected than the parotid, although the disease itself is not common; and exceptionally similar formations are observed

in the sublingual gland as well. The origin of the stones is referred to the entrance of tartar from the teeth into the duct of Wharton; other causes which are given are inflammation of the orifice of the duct with roughening of the walls, variation in the chemical composition of the saliva or its mixture with organic material, and exceptionally also obstacles to the outflow.

So long as the stones are small the manifestations which they arouse are slight, but even large stones several centimeters in length may cause no symptoms. Complaint first arises only when the accompanying inflammation causes a painful swelling of the gland, or when pus forms. The continuous flow of purulent secretion, as a rule, soon induces a troublesome stomatitis which may gradually involve the entire oral mucous membrane, but particularly the lower gum and the tongue; it is recognizable by the foul odor. Advanced phlegmonous inflammations occur rarely after the formation of concretions. More frequently localized purulent infiltrations limited to the bed of the gland and the contiguous portions of the floor of the mouth are observed, as well as fistulæ.

The diagnosis of salivary calculi is based upon the painful swelling of the gland, upon the findings on palpation, if the stone in the duct projects through the floor of the mouth, upon the extravasation of small points of pus on pressure over the infiltrated area, and finally upon the X-ray. Painful attacks of retention of saliva also point toward the disease. These may repeat themselves at every meal, and they arise when the concretion closes the duct like a valve. But since salivary secretions ordinarily cause the formation of a diverticulum in the duct, the sudden rise and disappearance of such salivary tumors are lacking in the majority of cases.

With the formation of concretions in the parotid or in its duct, acute salivary tumors may also arise, but the diagnosis of stone should not be based upon this alone, as exactly the same manifestations as those of a valve stone are aroused in this gland by dilatation or cystic enlargement of the duct.

Treatment is limited in these infrequent cases to removal of the stone through an incision in the oral mucous membrane; this is most advantageously undertaken in stone formation in the duct of the parotid, since total extirpation of this gland, as already stated, entails danger to the facial nerve. With concretions in the submaxillary gland, on the other hand, removal of the entire gland

is advisable, even if a single stone is to be felt under the oral mucous membrane in Wharton's duct, or even if one projects from the duct into the oral cavity. For extirpation alone removes with assurance the causes of stone formation within the gland structure, while with a stone in the duct the parenchyma of the gland is usually so altered secondarily or so filled with abscesses that only complete removal of the organ, together with its capsule, promises a cure. The following case shows how a submaxillary gland may be extirpated.

EXTIRPATION OF THE SUBMAXILLARY GLAND

A fifty-year-old man suffered for several years with chronic inflammation of the left submaxillary gland. In the weeks just preceding operation, repeated swelling occurred in the region of the gland, with pain, which radiated mostly to the tongue. Usually the attacks subsided after a few hours with a strong secretion of saliva, which at times was mixed with pus. In addition the patient suffered frequently from inflammation of the neck. With the X-ray a shadow about 2 cm. long could be seen in the middle of the swollen area, evidently referable to the submaxillary gland.

Incision was made parallel to the lower jaw from before backward, a finger's breadth below its margin, through skin, fat, platysma, and fascia, thus exposing the surface and the lower margin of the gland (Fig. 419, Plate 73). Then the gland and its thickened capsule, transformed into a hard tumor, was lifted up with the finger from the mylohyoid muscle below, whereupon a large vein which ran close to the tumor had to be double tied and divided. As the gland was loosened up farther from the substrata, a salivary stone came into view at its anterior margin. As the blunt dissection continued, the facial artery appeared at its posterior upper margin giving off a branch to the gland. This was immediately tied, but the vessel itself was displaced backward and upward.

The gland, freed up still further from above by blunt dissection, could finally be displaced from the wound, and the lingual nerve also came into view at the upper margin of the tumor. It was so intimately attached to the capsule of the gland that it could not be freed by blunt dissection, but had to be dissected off by scissors (Fig. 419, Plate 73). This being done, the gland hung only by its duct (Fig. 420, Plate 73), which was put under strong tension

Extirpation of the submaxillary gland.

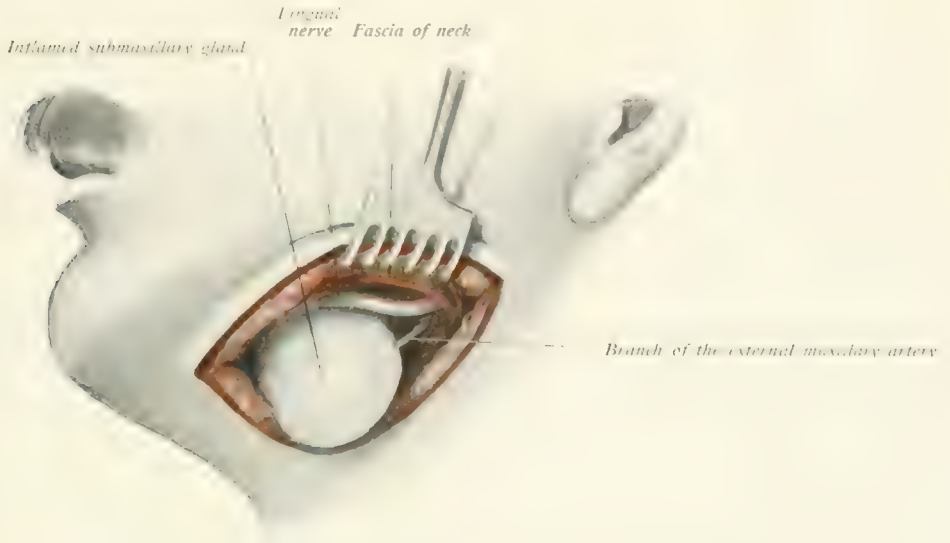


Fig. 419. Exposure of the enlarged submaxillary gland.

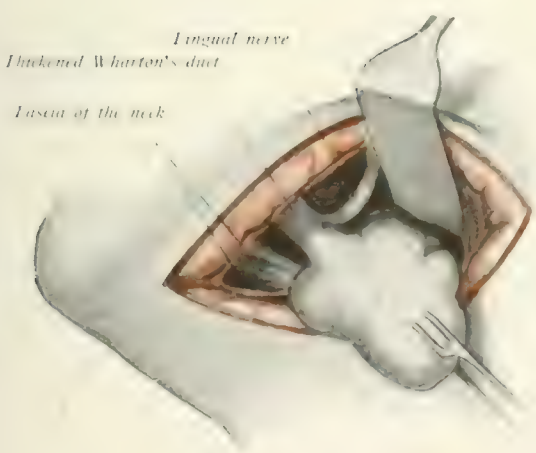


Fig. 420. Delivering the salivary gland.

Fig. 421. Floor of the wound cavity.

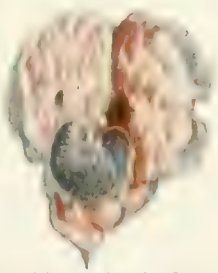


Fig. 422. The submaxillary gland after section, showing a calculus in the enlarged duct.

by seizing the gland with forceps and pulling it upward, and was divided close under the oral mucous membrane, together with the facial artery. The nerve remained wholly unharmed. At the floor of the oral cavity (Fig. 421, Plate 73), after the extirpation, the digastric, mylohyoid and hyoglossus muscles were exposed under the mucous membrane. No deep sutures were placed on account of the danger of infection, the wound cavity was loosely packed with iodoform gauze, and the skin alone was united by a few sutures over the packing.

The specimen on being split longitudinally showed an unusually enlarged duct which was filled peripherally by a stone 2½ cm. long, and at its greatest circumference nearly 2 cm. wide. On the third day after operation the packing was removed, and in its place a short drainage-tube was introduced. This could also be dispensed with after the sixth day, and the patient left the hospital with the wound practically entirely healed.

SALIVARY CYSTS

True cysts filled with mucous fluid may develop in the parenchyma of the salivary glands as well as in the duct wall. With regard to their origin stenosis of the duct as the result of connective tissue formation or some other obstruction of the means of exit, or a disturbance of the fetal development of the floor of the mouth has particularly to be considered; or the case may be one of inclusion of displaced embryonal cells or of a true cystic tumor. Mucous cysts are ordinarily to be considered, however, as simple retention cysts, and are treated accordingly.

They are most frequently observed as the so-called ranula, in the sublingual and parotid glands and in the glands of Nuhn, which are situated in the tip of the tongue. Since the ducts of the sublingual gland as well as those of the glands of Nuhn are short and of small diameter, in these glands cysts of the duct cannot be differentiated clinically, and often not even anatomically, from cysts of the parenchyma of the gland. Duct cysts of the parotid and of the submaxillary gland, on the other hand, usually cause a complete closure of the affected duct and are then demonstrable as tense spindle-shaped or club-shaped tumors under the oral mucous membrane. These salivary tumors disappear as soon as the duct is probed or its patency restored in some other manner, so that the cyst may empty itself.

As with other glands rich in parenchyma, for instance the liver and kidneys, under the influence of a long-standing obstruction to the outflow the secretion gradually diminishes, and in the salivary glands it ceases entirely. Cysts of the salivary ducts never reach any considerable size. Cysts of the parenchyma are at times multiple or multilocular. Their origin depends upon the fact that with the closure of one radical of the gland the duct of a neighboring portion is obstructed, and with the increase in size finally only the connective tissue partition remains as a thin septum.

Particular symptoms are aroused by cysts of the glands of Nuhn as well as by those of the sublingual gland, the first particularly in infants, by causing difficulty in sucking, the latter in older children and adults by the fact that the cysts lift the tip of the tongue against the palate and interfere with eating and talking. Cysts of the glands of Nuhn are usually congenital. They occur on the tip of the tongue as nodules the size of a cherry stone or larger, and are covered only by a thin layer of mucous membrane through which the fluid content may be seen with a bluish tint. Ranula on the other hand is very rarely congenital, but usually develops in later years. Its situation corresponds to that of the sublingual gland, and as a single cyst, or in groups, it is found on the side or under surface of the tongue near the tip, or on the floor of the mouth. The duct of the submaxillary gland, and the sublingual fold which this forms, as well as isolated veins, are likely to run over the thin-walled bladder-like tumor or close by it at one side. Its contents, as with all salivary cysts, consist of a glassy, colorless, and somewhat tenacious mucus.

As to treatment of mucous cysts in general extirpation alone is to be considered. With intelligent patients, this may be carried out under local anesthesia after painting the mouth and tongue with a 10 per cent. cocain solution, and after a submucous injection of ½ per cent. novocain-suprarenin solution into both lingual nerves. Treatment by puncture, withdrawal of the contents and injection of tincture of iodine, is justified only in parenchymatous cysts of the parotid about the size of a hazel nut which lie near the skin, because after wide external incision and the injury of the gland which unavoidably results, a permanent salivary fistula is very likely to occur. This procedure is advisable also for cysts of the duct of Steno. For all other cysts, however, complete extirpation of the affected gland is demanded for permanent relief, and

Extirpation of a ranula and of the sublingual gland.

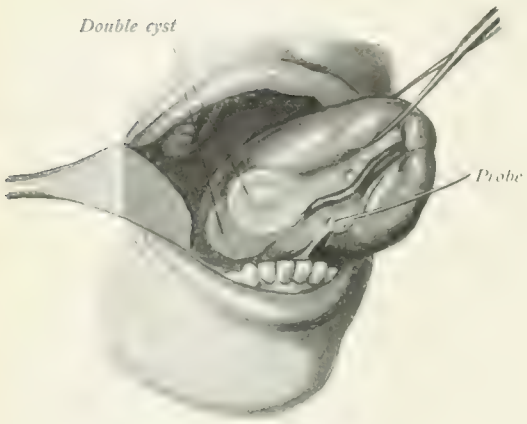


Fig. 423. The tongue is drawn out, and a probe introduced into Wharton's duct.

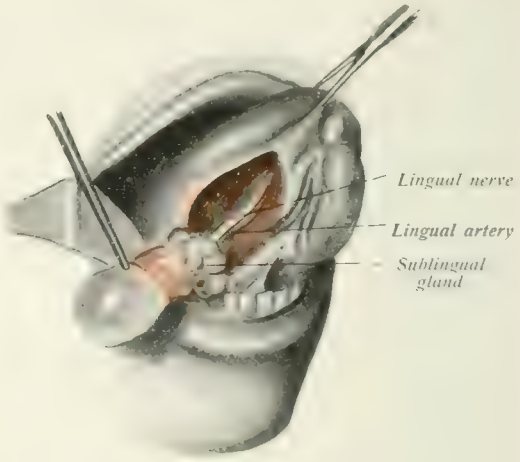


Fig. 424. Freeing up the sublingual gland.

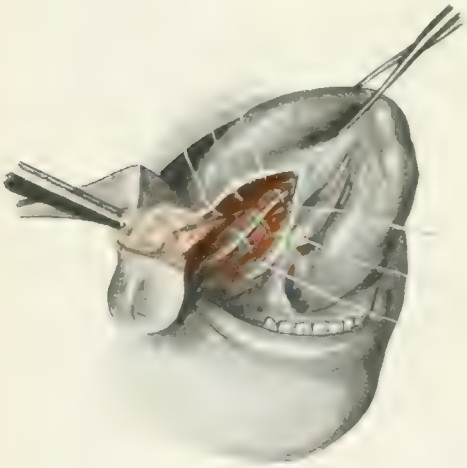


Fig. 425. The lingual nerve is protected by suturing the tongue muscles over it.

Fig. 426. Superficial suture of the mucous membrane.

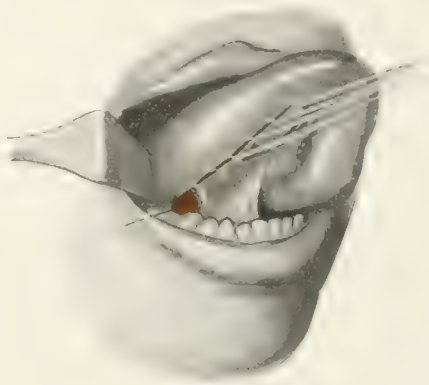


Fig. 427. Completion of the superficial suture of mucous membrane.

in ranula, at least, the dissection and removal of the entire sac. This may be accomplished without difficulty after careful incision of the mucous covering, even if the wall is injured in being freed out and the contents emptied before the extirpation is complete. In order to avoid recurrence, the sublingual gland should be removed entire if the ranula is composed of several cysts. This procedure is demonstrated in the following case:

EXTIRPATION OF A RANULA TOGETHER WITH THE SUBLINGUAL GLAND

In a thirteen-year-old girl, a typical ranula had developed upon the right side in the course of two months, causing marked difficulty in speech and deglutition. On the lower side of the right half of the tongue two cysts the size of a hazel nut were found contiguous to each other, separated superficially by a furrow, but joined at the floor of the mouth (Fig. 423, Plate 74). Several veins, the sublingual fold, and the orifice of the duct of Wharton lay medial to both cysts.

Before beginning the operation the tongue was painted with 10 per cent. cocain solution and 5 c.c. of ½ per cent. novocain-suprarenin solution was injected in the course of the two lingual nerves, as far back as possible on either side of the tongue. The tongue could then be seized with bullet forceps without causing pain and pulled upward and to the left. In order to make the operative field conveniently approachable, the mouth was held wide open by a gag introduced on the left side, and the right corner of the mouth as well as the lower lip was drawn outward and downward by a retractor. Then a hair-sized probe was introduced into the submaxillary duct in order to demonstrate its relation to the two cysts and as far as possible to prevent injury (Fig. 423, Plate 74). Next the mucous membrane around the base of the anterior cyst was incised a slight distance from its margin so that it could be drawn up with forceps without injuring the cyst wall.

As the cyst was being shelled out by blunt dissection, the sublingual gland came into view on its median side, from which it could not be separated without danger of tearing (Fig. 424, Plate 74). For this reason it was considered advisable to extirpate the gland also, a technique, as we have already said, which is particularly recommended for the complete cure of such cysts. The sublingual artery had to be isolated and tied, as well as the terminal branch

of the lingual artery, which was visible just under the exposed anterior section of the lingual nerve (Fig. 424, Plate 74). After freeing up the sublingual gland still further, in connection with the two cysts, the entire formation was held behind to the tongue and floor of the mouth only by a bridge of mucous membrane. By applying a clamp to this strip, the entire wound cavity could be drawn forward to the line of the teeth and rendered thoroughly visible. The wound cavity was closed by three deeply placed catgut sutures which did not include the mucous membrane, so that the lingual nerve, which was exposed for a considerable distance in the depths of the wound, was adequately covered (Fig. 425, Plate 74). After tying the three catgut sutures, the originally deep wound became fairly level.

The remaining wound of the mucous membrane and muscle was closed by superficial sutures of catgut; the first three sutures placed in the anterior portion of the wound at the tip of the tongue, were left long to hold by, so that after removal of the bullet forceps they could be used to draw the tongue out (Fig. 426, Plate 74). Finally the remnant of the sublingual gland, together with the cyst, which was still in connection with the deeper layers, was completely freed in the region of the posterior angle of the wound, and this was united by three more catgut sutures, so that a linear suture line resulted (Fig. 427, Plate 72). A small opening was left close to the alveolar process behind into which a strip of iodoform gauze was introduced. In order to be able to draw the tongue out readily in case of swelling, the superficial sutures which had been used to hold by were left long. Several days later, when this danger no longer existed and the wound edges were adherent, these were removed. On the tenth day after operation the child was discharged well.

Ranula does not always develop upward in the direction of the tongue, it may frequently remain entirely invisible in the floor of the mouth and project below the chin in the submental region. This happens not only in very large cysts of the sublingual gland, but always if a ranula develops in a lobule of the gland which is situated anteriorly between the muscles of the floor of the mouth. Congenital cysts of the sublingual gland have a preference for just this submental location, where one is led to infer that a portion of the gland displaced forward has had its secretion obstructed as

the musculature of the floor of the mouth developed. Incomplete excision, just like incision, and curettage through the wound, always leads to recurrence or to a persistent fistula. Only radical extirpation of the sublingual gland after wide division of the skin and fascia covering the cyst, and after penetration between the muscle layers as far as the oral mucous membrane, guarantees a permanent cure of the cyst or of the fistula which arises after incomplete attempts. The following case may serve as an example of this procedure.

EXTIRPATION OF A CONGENITAL FISTULOUS RANULA

A child sixteen months old was born with a tumor on the floor of the mouth which projected under the skin of the neck. At four weeks this tumor was incised in the neck by a physician, whereupon a fistula arose, which at first secreted a slimy and then a mucopurulent fluid. This condition remained unchanged during the following year, in spite of the fact that another larger incision was made and later a curettage attempted. If the copiously secreting fistula closed, the child developed fever; when it broke open again it emptied itself of a large amount of viscous pus and the child felt better. In order to bring this condition to an end, the fistula had to be entirely dissected out.

From the origin of the disease, it could evidently be a case only of fistulous ranula, for besides cyst formation in the sublingual gland, dermoid was the only thing to be considered in differential diagnosis. Against this was the clear mucous content, which emptied itself at the first incision; also dermoids in this region are always connected with the hyoid bone, which could be determined definitely by introducing a probe. An incomplete branchial fistula which was rendered complete by external incision seemed improbable because median fistulæ in this location are always below the hyoid bone, and lie between it and the middle process of the thyroid gland. Moreover cysts of the thyroglossal duct or those arising from inclusions of epithelium from the oral mucous membrane are never found fully developed at birth, but are more likely to form in later years.

Extirpation of the fistulous sac was carried out under general anesthesia. A middle-sized probe was introduced in the middle line as far as the oral mucous membrane, and after repeated attempts it found its way farther upward and to the right against

the ramus of the lower jaw, but it would not go to the left. The probe was allowed to remain in place. A skin incision in the middle line between chin and hyoid surrounded the fistulous opening and was carried down to muscle (Fig. 428, Plate 75). The orifice of the fistula was dissected out, together with a thick layer of tissue, and seized with the probe still *in situ* by a clamp (Fig. 429, Plate 75). Then under light tension the sac was freed up from between the fibers of the hypoglossus muscle with knife and scissors, taking care not to injure it, and in this process the upper margin of the hyoid bone was exposed. This dissection consumed a considerable time because, on account of the long-standing purulent discharge, blunt dissection was found impossible.

Proceeding farther toward the floor of the mouth on the right side the anterior margin of the mylohyoid muscle and the submaxillary gland had to be exposed, and they were separated from each other by blunt dissection (Fig. 430, Plate 75). The cystic sac continued upward and to the right in the direction of the styloid process (Fig. 431, Plate 75). This lobe was freed up with difficulty step by step with scissors under guidance of the probe which had been passed farther in. On the floor of the mouth to the right of the frenulum, the oral mucous membrane was inseparably connected with the sac so that a narrow strip running near the frenulum had to be excised with it (Fig. 432, Plate 75).

After the extirpation was completed, the oral mucous membrane was sutured through the mouth with four interrupted catgut sutures (Fig. 433, Plate 75). Then through the external wound the submaxillary gland was replaced in its original pouch and held in this position by a few catgut stitches, in this way supporting the mucous membrane suture from below. Finally the muscles of the mouth, which had been dissected apart, were united with catgut, in this way assuring the suture of the gland (Fig. 435, Plate 75). The rest of the shallow wound cavity, on account of the old infection, was loosely packed with vioform gauze, the end of the packing and drain were passed out at the lower angle of the wound, except for which the skin wound was closed with silk sutures.

The child stood the long operation well. After four days the packing, and in four days later the drain and the sutures, were removed; the wound of the oral mucous membrane was completely closed. The child was discharged well.

Submental extirpation of a fistulous ranula.

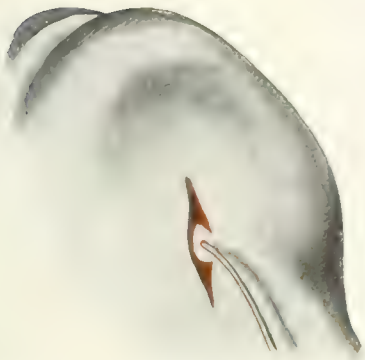


Fig. 428. A probe is passed into the fistula and the skin incised about its opening.

Fig. 429. The probe is clamped in place.

Fig. 430. The sac is dissected away.

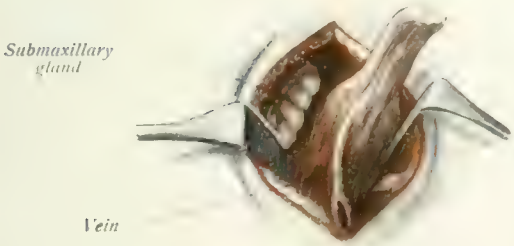


Fig. 431. Exposure of anterior margin of the submaxillary gland.

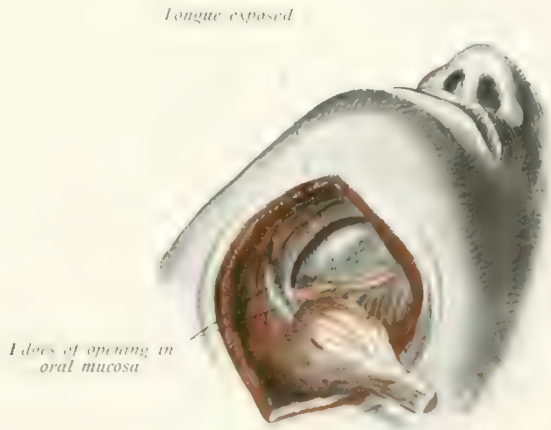


Fig. 432. Opening up the oral cavity from below.

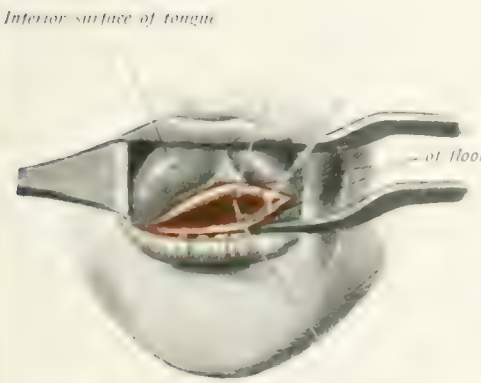


Fig. 433. Suture of mucous membrane.

Fig. 434. Completion of the suture.

Fig. 435. Suture of the floor of the mouth.

TUMORS OF THE SALIVARY GLANDS

Of the salivary glands the parotid is particularly rich in tumor formations, among which we find a whole series of benign and malignant growths. Half way between the two forms we find the so-called mixed tumor, which is typical in the salivary glands. These may for a long time remain small and benign; but after many years a metamorphosis may occur, following which they become fully as malignant as sarcoma and carcinoma.

Of the benign new growths, the *cavernous angioma* and *lymphangioma* which arise in the parotid itself, or invade it from neighboring tissues, have surgical significance in so far as they may infiltrate the glandular tissue and cannot be extirpated without extensive injury of the parotid and the branches of the facial nerve. Accordingly, for their destruction the less radical means are usually employed, such as the magnesium membrane of Payr, X-rays or radium; electrolytic methods and the injection of caustic agents have also been tried. Clinically these tumors ordinarily cause few manifestations and only when lying down or in stooping does the sudden filling of the numberless vascular spaces cause trouble. By pressure from without the fluid content may be squeezed out again. If the tumor sloughs on the surface or threatens by rapid growth to destroy the cheek or, in the depths, the skull, it must be completely extirpated in the manner which was described on page 93 for a cavernous angioma of the cheek.

Less harmful than the vascular tumors is the *intra-capsular lipoma*, which may be shelled out without difficulty after division of the parotido-masseteric fascia. The same is true of the hard *fibroma*. As the benignity of this tumor cannot always be determined with assurance by palpation and the other clinical findings, and on the other hand, the danger always exists that it represents a slowly growing sarcoma or one of the mixed tumors, radical removal is to be advised. It is carried out in the following manner:

EXTIRPATION OF A FIBROMA OF THE PAROTID

In a thirty-year-old man a tumor, which had grown slowly over a course of several years to the size of a plum, was situated over the right articulation of the jaw just in front of the origin of the lobule of the ear and close below the zygoma. Its consistency was firm and its surface had become adherent neither to skin nor

to the jaw-bone. Extirpation was carried out under local anesthesia with ½ per cent. novocain-suprarenin solution; the skin over the point of greatest projection was infiltrated subcutaneously, and the growth itself was infiltrated subfascially by injections made at each of the four poles.

In order to avoid the fibres of the facial nerve so far as possible, the skin incision, starting from the middle of the tragus, was made directly down to the tumor and parallel to the zygoma, and went across its summit (Figs. 436 and 437, Plate 76). In the anterior region of the incision, in order to carry out the blunt dissection under control of the eye, the posterior margin of the masseter muscle had to be nicked (Fig. 437, Plate 76). The tumor evidently belonged to the parotid, although it could be shelled out by blunt dissection above and externally, but medially and below fasciculi of fibers passed over into the normal parotid tissue, which was visible at this point. In order not to leave any of the tumor behind, the parotid tissue, which came into view when tension was exerted on the tumor, was divided step by step with scissors and every spurting vessel was seized and tied (Fig. 438, Plate 76).

For the sake of assurance, the periosteum was removed from the lower margin of the zygoma. The superficial temporal artery, which came into view behind on shelling out the upper pole, could be freed up by blunt dissection and preserved. Finally the tumor was held only by a pedicle the size of a lead pencil to the medial segment of the parotid (Fig. 439, Plate 76), and after this was divided the extirpation was complete. The uninjured capsule of the articulation of the jaw lay exposed, as well as 3 cm. of the zygoma and the cut surface of the parotid.

On microscopical examination the tumor was found to be a smooth walled and, with the exception of the region of the lower pole, encapsulated fibroma which, on account of the richness of the nuclei in places, aroused suspicion of being cancerous. The wound was closed by suture of the skin and a moderate sized drain which reached to the articulation of the jaw was left for two days after operation. Eight days later the patient was discharged. At first there was an insignificant salivary fistula, but in the course of another week this healed up. No trace of paralysis of the facial nerve was present.

Extirpation of a fibroma of the parotid.

Fig. 436. Skin incision.

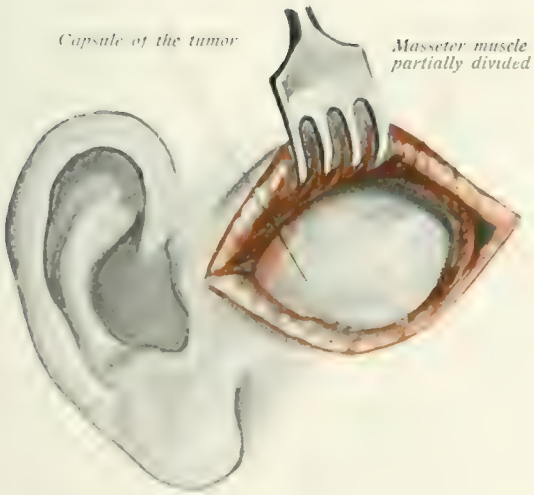


Fig. 437. Exposure of the surface of the tumor.

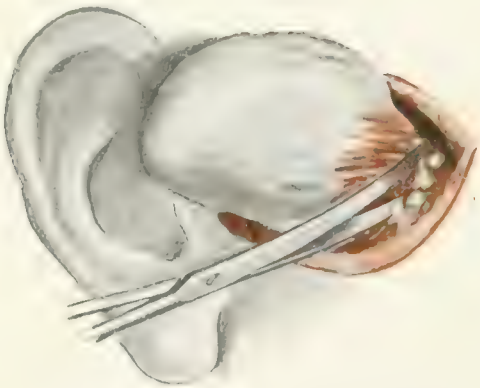


Fig. 438. Separation of the growth from the parotid gland.

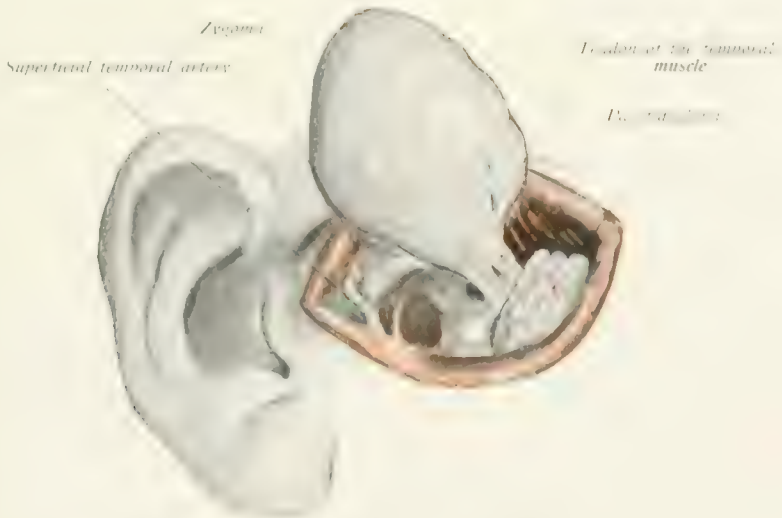


Fig. 439. The separation nearly completed.

MIXED TUMORS

More closely allied to the benign than to the malignant tumors is the characteristic tumor of the salivary gland, the so-called mixed tumor. Under this name we understand tumors which are composed of epithelial as well as of connective tissue elements, and in which the connective tissue portion is to be considered not only as the framework or stroma of the tumor, but also as a real constituent part of the parenchyma. The epithelial cells lie scattered in the form of isolated nests in the field or arranged in rows on both sides of clearly visible lymph capillaries; under certain circumstances there are also found accumulations of cells which are arranged in club-shaped forms and may be recognized as similar to the epithelial pearls found in skin cancer. In one tumor the epithelial cells may predominate, in another, the pure connective tissue elements and their manifold mucous varieties with cartilaginous or hyalin degeneration; and in other tumors all these forms may occur mixed with one another.

But since the epithelium of this tumor is not considered as such by many authors, but as endothelium, these tumors have been given the name of endothelioma and classified with the mesodermal tumors, the sarcomata. Even of the typical epithelial formations such as the epithelial pearls, it has been said that they may take their origin from endothelial cells. Recently we have been disposed, in spite of the rich content of connective tissue and its various degeneration forms, to classify the tumor with the epitheliomata and in its malignant metamorphosis with the carcinomata, particularly as in certain cases transition forms from the gland cells of the parotid to the tumor cells have been found, and with the aid of special staining methods in the protoplasm of the cells which were formerly called endothelial, the fibrillæ and the prickle cells which are typical only of epithelium have been demonstrated.

Even if the genesis and classification of these tumors have not yet been cleared up, nevertheless the richly variable picture of their structure offers the key to the irregularity of clinical manifestations which mixed tumors demonstrate above all others. A tumor is either as hard as cartilage and appears to be attached neither to the skin, the parotid, nor to the lower jaw, or it is a rather soft medullary mass with a clearly developed stroma, or finally it may be a fluctuating mucous growth with a very little firm ground sub-

stance. Practically all possess a capsule which definitely separates it from the skin and the parotid.

One of the peculiar properties of this type of tumor consists in the fact that they develop gradually, and require a decade or more to reach the size of a plum or of a small apple. A certain proportion of them persist a life-time without showing an increase in rapidity of growth and without overstepping a limited size, maintaining completely the benignity which these tumors as a class show at the beginning. With the majority, to be sure, the growth, at first exceedingly slow, after the passage of years suddenly accelerates to an extreme degree. Then, as a rule, the malignant transformation appears. However, tumors the size of the fist or even as large as a child's head, may preserve their benign characteristics unaltered.

The most important diagnostic signs of the mixed tumor consist in its free movability on the underlying tissues, its firmness of consistency, and the rather nodular and uneven nature of its surface. Moreover, the long, slow growth extending over the course of years is of diagnostic significance. The situation of the tumor is also significant, particularly if in the middle of the cheek-surface of the parotid, it projects as a well-outlined tumor under the skin, which even with very large tumors usually remains freely movable. Finally the majority of the mixed tumors grow over the posterior and later over the lower margin of the parotid and lift up the lobule of the ear from below. In pure carcinoma and sarcoma, on the other hand, the surrounding skin and deep-lying tissues are ordinarily infiltrated round about with tumor masses. The mixed tumor takes on this property of malignant tumors only after its malignant degeneration, and then over only a limited area. As a further point of differentiation, the neuralgia of the affected division of the trifacial, which so frequently accompanies sarcoma and carcinoma, as well as the facial paresis, which is not quite so frequent with these neoplasms, never occurs with mixed tumors.

In spite of the entire absence of symptoms mixed tumors should be extirpated as early as possible. As they occur usually in men, who as a rule have slight regard for the disfigurement which they cause, it is particularly the hindrance in chewing and talking which, in long-standing cases, leads to the institution of treatment. The extirpation is undertaken through an incision parallel to the fibers of the facial nerve, similar to that shown for fibroma of the parotid

(see p. 394, Plate 76), and is carried out so thoroughly that the capsule, particularly where the tumor is united internally with the parotid, is completely removed as well. If the removal of the capsule and of the fibers connecting it with the gland is not complete, danger of a rapidly developing recurrence exists, as is shown by many cases in the literature. In doubtful cases regard for the facial nerve itself should form no ground for an insufficient extirpation.

In the unusual event of a mixed tumor growing in the submaxillary gland, the entire gland is removed at once in connection with the tumor.

MALIGNANT NEOPLASMS

True *sarcoma* or *carcinoma* occur less frequently in the salivary gland than mixed tumors. As in other organs the development of sarcoma is observed at any period of life, but carcinoma occurs particularly in later years. Developing unobserved, at times the first symptoms or external visible signs are noticed at a time when operability may be open to question. The tense parotido-masseteric fascia and the fascia covering the submaxillary gland particularly act as a considerable hindrance to the early demonstration of localized foci in the gland. On the other hand the rapidly growing soft neoplasm is inclined under the uniform pressure of the fascial covering to grow toward the depths rather than toward the surface of the cheek. In advanced cases, on account of the infiltrating growth of the malignant tumor, differentiation from inflammatory processes in the gland is also in many cases impossible.

The resemblance between carcinoma of the salivary gland and of the breast is striking. The soft medullary form, rich in cells, the less rapidly growing cylinder cell carcinoma, in which the parenchyma lies arranged in the form of gland tubules, and the hard, comparatively benign scirrhous type as well, are all observed among the cancerous growths. Diagnosis involves great difficulties so long as the soft cancer has not formed nodular or papillary infiltrations, usually of a bluish red color, on the margin of the jaw or on the skin of the cheek, less frequently on the oral mucous membrane, or so long as the cheek does not assume an unevenly nodular and shrunken appearance by scar formation in the scirrhous type. The manifestations which appear with the extension of the carcinoma, such as difficulty in opening the jaw, neuralgic pains, facial paresis and disturbances of hearing, are not present at the beginning.

These difficulties in diagnosis explain the inoperability and the rapid recurrence of most of the carcinomata in this region which come to the surgeon.

Many sarcomata of salivary glands, on the other hand, present a relative benignity. These are the fibro-sarcomata, which clinically and histologically differ only slightly from pure fibromata. Like these, they possess, except at the point of transition from the glandular tissue, a definite capsule, which may, however, be wanting in exceptional cases. Their consistency is hard; their surface is ordinarily smooth; they grow much more slowly than the other sarcomata and form no metastases. Their extirpation is carried out like that of fibromata and corresponds to the technique described on page 394, Plate 76.

Round-celled sarcomata, on the contrary, are classified with the malignant tumors of the salivary glands. They offer greater difficulties to an early diagnosis than the soft cancer, since they first develop unnoticed, but later proliferate very rapidly behind the ramus of the jaw between the great vessels, downward toward the neck or into the external auditory canal. They are not infrequently confused at first with inflammatory or tuberculous lymph nodes.

An intermediate place between the two described forms of sarcoma is taken by the spindle-celled sarcoma, which is found also in the salivary glands.

Treatment of all the malignant tumors can consist only in their radical removal, together with the entire organ from which they take their origin. In the submaxillary gland no difficulties arise, but it is different with the parotid, where frequently in addition to a portion of the large cervical vessels, sections of the jaw or even of the auditory canal (with under these conditions the trunk of the facial nerve) must also be sacrificed. If the radical removal of the growth is successful, it is justifiable at the end of the operation to attempt the repair of the dissected facial nerve by implantation, as will be shown in the following case.

EXTIRPATION OF SARCOMA OF THE PAROTID WITH RESTORATION OF THE FACIAL NERVE

The patient had noticed twelve years before admission a tumor the size of a bean behind the right ear, which gradually increased in size until it became as large as an apple. After a year a radical removal was performed with preservation of the facial nerve. Ac-

Extirpation of a sarcoma of the parotid.

Fig. 440. Sarcoma of the parotid gland.

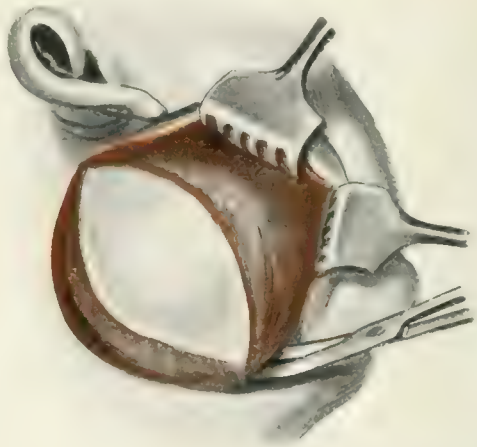


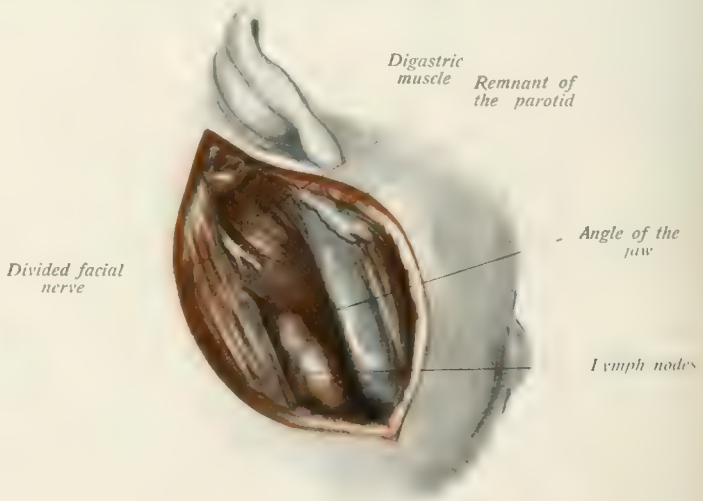
Fig. 441. Skin incision, and beginning of the dissection.

Fig. 442. Ligation of the vessels entering the lower margin of the tumor.

External auditory canal, opened from without
Deep temporal artery
Facial nerve
Resected portion of auditory canal, adherent to the tumor

Fig. 443. Exposure of the upper portion of the tumor.

Fig. 444. Exposure of the facial nerve at the



cording to report, it was a case of spindle-cell sarcoma. About ten years later the tumor began to develop again in the scar until it reached the size of a child's fist. Our examination showed that the chief mass belonged to the section of the parotid gland which is situated behind and under the lobule of the ear, and it consisted of two nodular formations which were separated from each other by a furrow which corresponded to the old operation scar (Fig. 440, Plate 77). It was movable upon the underlying tissues, but the skin could be lifted away only over the lower nodule, while it had grown fast to the upper one which was twice as large and showed inflammatory reddening at one softened place on the surface.

The portion of the skin which was adherent to the tumor and the retracted scar were surrounded by an oval incision, and the shelling out of the tumor was undertaken first from the anterior and then from the posterior wound margin by blunt dissection, with the aid of an occasional clip of the scissors (Fig. 441, Plate 77). In isolating and lifting out the tumor from below and in front, it was evident that at this point it went over into the parotid tissue by a broad base; a network of veins and a large artery, presumably the deep temporal artery, were divided and double-tied (Fig. 442, Plate 77). In dissecting out the upper pole, the insertion of the sterno-mastoid had to be separated from the anterior margin of the mastoid process. The tumor had grown so adherent to the outer wall of the auditory canal that a section of the cartilage the size of a finger nail had also to be cut out (Fig. 443, Plate 77).

After all connective tissue and muscular connections had been divided, the tumor could be pulled sharply outward. In this way the facial nerve was visible for a considerable distance from its exit at the stylo-mastoid foramen. In front it proceeded into the tumor, so that after completion of the dissection this hung only by the facial nerve. The attempt to dissect out the nerve from the tumor as far as its branches (Fig. 444, Plate 77) failed, as the branches went over inseparably into the tumor mass. Accordingly it was divided near the stylo-mastoid foramen and the tumor, together with the contiguous portion of the parotid gland, was extirpated by a wide margin. In front under the skin of the cheek a portion of the parotid was preserved. After removal of the neoplasm the posterior margin of the jaw was exposed. In order to remove a lymph node which lay at the anterior margin of the sterno-mastoid, the muscle was pulled backward with a blunt hook.

whereupon, covered by the stylohyoid and the digastric muscles, the internal jugular vein, with the spinal accessory nerve lying upon it, came into view.

ANASTOMOSIS OF THE FACIAL AND HYPOGLOSSAL NERVES

As the facial nerve had to be sacrificed in connection with the tumor, it was determined to restore its function by a neural anastomosis. For this purpose it was decided to use the hypoglossal nerve. In order to preserve the innervation of the tongue muscles so far as possible, it was planned to use only the descending branch of the nerve, that is to say, the branch which splits off from the arc of the hypoglossal nerve and runs downward between the internal and external carotid arteries, covered by the internal jugular vein (Fig. 446, Plate 78). But it was seen that this branch was, as usual, too poorly developed to serve as a sufficient source of supply for the peripheral stump of the facial. Accordingly it was determined to use the hypoglossal nerve itself for the anastomosis.

To expose it, the posterior belly of the digastric muscle was separated by blunt dissection from the stylohyoid muscle and displaced backward by a blunt hook. Whereupon the carotid artery came into view in the depths, and the hypoglossal nerve was isolated from the connective tissue sheath covering the great vessels (Fig. 447, Plate 78). The main portion going to the tongue muscles and the descending branch lying near by were easily separated by anatomical forceps. Since a rather long piece of the facial had been resected in connection with the tumor, its peripheral stump had to be sought in the parotid. In order to have as large a branch of the nerve as possible, and not one of the smaller subdivisions to unite with hypoglossus, the cut surface of the parotid was freshened again above and below after the skin of the cheek had been drawn forward with a retractor, and on it a nerve fiber was isolated. With the aid of a weak Faradic current, which could just be felt on the finger tips, this branch was recognized as the common trunk for the corner of the mouth and of the eyelid.

After this necessary determination, the hypoglossal nerve was divided fully 3 cm. peripheral to the point where the descending branch came off, and its central stump was united with the peripheral portion of the facial nerve (Fig. 448, Plate 78). The suture was carried out with the finest needles and paraffin silk, such as are used in blood-vessel surgery.

Anastomosis between the facial and hypoglossal nerves.

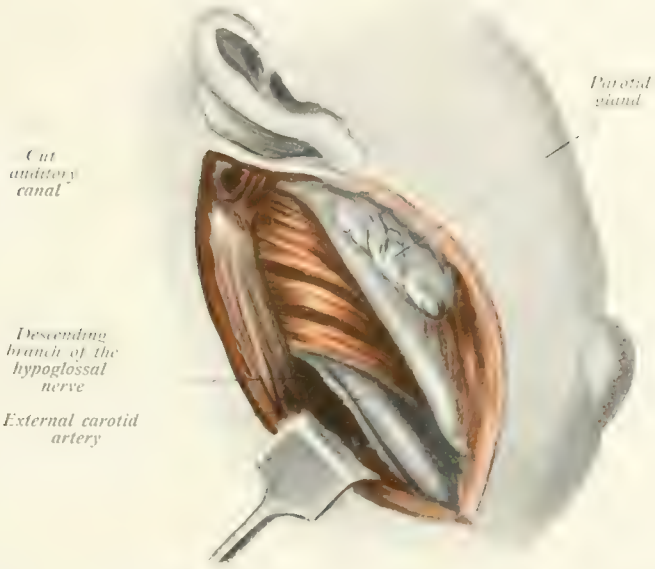


Fig. 446. Exposure of the carotid artery and the descending branch of the hypoglossal nerve.

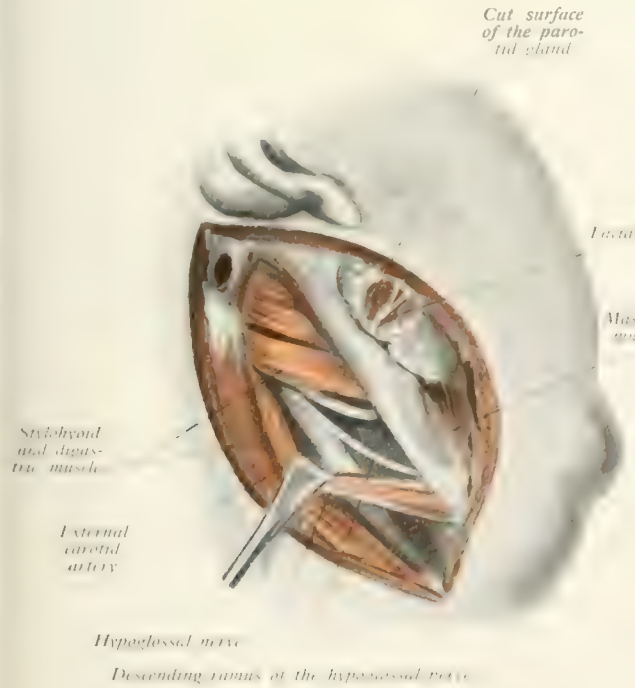


Fig. 447. Exposure of the hypoglossal nerve.

Fig. 448. Anastomosis completed.

After the hole in the cartilage of the auditory canal was closed with buried catgut, the skin wound was sewed up, a short strip of gauze and a drainage-tube being left behind in the lower corner.

The wound healed without incident, and without rise in temperature; packing and tube were removed on the fourth day and the patient was discharged after ten days with complete paralysis of the right half of the face. Two years later she was re-examined. The scar near the jaw was somewhat retracted, the entire half of the face and the affected half of the tongue were atrophied. There was no disturbance in chewing or talking. The right corner of the mouth dropped somewhat and the tongue, on being protruded, could not be moved of itself. Likewise the eyelids of the right eye could not be closed; in other words, the function had not been restored in the facial nerve. Although the paralysis caused no trouble, the patient complained of very severe neuralgic pains in the face and in the occipital region. Examination revealed that the middle ear and the neck were infiltrated with sarcomatous masses. A new operation appeared inadvisable.

CHAPTER 17—SURGERY OF THE FACIAL AND CERVICAL NERVES

TREATMENT OF FACIAL PARESIS: NERVE ANASTOMOSIS

In the patient just reported in whom a portion of the facial nerve was removed with a sarcoma of the parotid gland, a nerve of considerable size, but one which in case of necessity could be dispensed with, was divided and transplanted into its peripheral stump. This procedure harks back to the nerve grafting originated by Létiévant for nerves of the extremities, though it was first employed for paralysis of the facial nerve, following purulent otitis media in a child, in 1895, by Ballance,* but without success. Three years later the procedure was undertaken independently by Faure † and Furet. Both of these authors, and later others, transplanted into the peripheral stump of the facial the completely divided accessory nerve, or at least one of its branches, that for the sternomastoid or the trapezius. Körte ‡ used the hypoglossal nerve for anastomosis, and this technique became accepted by later operators in the treatment of facial paresis.

After the nerve ends have healed together the impulses originally intended for the tongue, in case the hypoglossal is employed, are carried over into the muscles supplied by the facial. Accordingly, it is the rule that at first muscle contractions take place in the face only simultaneously with movements of the tongue. Thus the affected eye can be closed or the corner of the mouth lifted only if the tongue is projected. However, the patients learn in time to convert the center for the affected half of the tongue into a center for the movements of the affected side of the face. The hypoglossal nerve is particularly well disposed for transplantation and re-education, because the facial and hypoglossal centers lie close together in the cortex; also it is well developed for anastomotic purposes, and the paralysis and atrophy of the affected half of the tongue, which sets in after division, as well as the disturbances in swallowing and talking, are comparatively minor difficulties.

* Ballance: St. Thomas's Hospital Reports, 1895.
† For the literature, see Manasse: Archiv. f. Chir., Vol. 62.
‡ Deutsche med. Wochenschr., 1903, No. 17.

The muscle defect which follows if, according to the original technique established by Ballance and Faure, the spinal accessory nerve or one of its branches is employed instead of the hypoglossal, may also be unpleasant because after its division the arm and shoulder may suffer considerable loss of power, and rotation of the neck be impeded. Moreover, after spinal accessory anastomosis, the re-education of the facial muscles for the isolated voluntary movements is said to be less frequently successful, and, as may be seen from cases in the literature, movements of the face always remain combined with simultaneous movements of the arm or shoulder. Theoretically this could be entirely overcome if, out of regard for the unavoidable atrophy and paralysis which results with either the hypoglossal or the spinal accessory nerve, complete division were avoided and the peripheral stump of the facial only implanted laterally in one of the above nerves; then the contractions of the facial muscles would always be simultaneous with the movements of the muscles supplied by the nerve involved. In practice this method has, however, failed to give satisfactory innervation, and at the present time it is not generally recommended.

Apparently for the success of the transplantation the maintenance of conductivity in the peripheral stump is decisive. For in a series of cases, in spite of a completely successful anastomosis, the expected activity did not appear, a manifestation which is observed similarly in paralysis from other causes in otherwise intact nerves of the face. In cases of paralysis existing over several years, the excitability is determined beforehand by electrical functional tests, while in fresh division of the nerve, for example during an operative procedure, electrical stimulation serves only to determine the proper branches. Lost excitability from the facial point, or a complete reaction of degeneration of the affected facial muscles, disturbs the outlook for a successful result.

Failures may also be blamed upon faulty technique in suturing. One should take care that in anastomosing the two freshened ends of the nerves, the suture does not seize too broad a section of the nerve and choke it off. The suture is best carried out with a fine round needle which is introduced in one stump a few centimeters above the end from without and brought out near the margin of the cut surface, and then is introduced in the other cut surface from within outward. In this way the knot comes to lie outside. Two such sutures through the substance of the nerve ordinarily

suffice, but one or two more sutures may be placed through the perineureum above. Whether catgut, linen, or fine silk is chosen is unimportant. Only one should be careful not to draw the threads too tightly, otherwise the cut surface of the two stumps will not be in exact apposition for proper proliferation of the divided nerve fibers, but will lie bent at an angle with their connective tissue sheaths in apposition. In the lateral anastomosis which is less to be recommended, the intact nerve from which the voluntary impulse is to be conducted is incised longitudinally on one side and the peripheral stump of the facial nerve is fitted into this slit. A few sutures, which only penetrate superficially, hold the two nerves in apposition.

If the stumps are found to be too short for a direct anastomosis, plastic methods must be employed; for instance, the formation of a pediculated flap from one or both ends. These are obtained by splitting off one-half of the nerve from one stump longitudinally, but not as far as the cut end, turning the flap down on the pedicle which is left at the cut end, and uniting it with the other stump or a flap similarly cut from it.

The first result of a successful nerve anastomosis consists, as a rule, in the return of tonus in the facial muscles which up to that time were paralyzed. For the patient the return of muscle tone in itself means improvement, for the disfiguring droop of the paralyzed corner of the mouth appears to be overcome, at least in rest. After a certain time, in the favorable cases, there appear the first associated movements in the region of the facial nerve on lifting the upper arm, if the accessory nerve has been employed for the anastomosis, or on protruding the tongue if the hypoglossal nerve has been used. A complete success, with isolation of the muscles which before were paralyzed, that is to say, a restoration of the ability to move them without use of the tongue or of the arm, is, to be sure, obtained only in the most infrequent cases. To bring about this result, a course of exercises of the facial muscles and strengthening of the power in the new nerve route by electrical treatment, must be carried out strenuously for many months.

The replacement of the central facial stump by another good functionating motor nerve is indicated not only after extirpation of tumors, but also after penetrating or incised wounds, if primary direct union by suture has not succeeded or has had to be postponed. Transplantation is also attempted in permanent paralysis

resulting from purulent otitis media, from freezing or the action of toxic substances. The following case demonstrates the method of exposing the nerves and the technique of anastomosis.

In a nineteen-year-old girl who had had measles as a child, but had otherwise always been well, contractures had developed at the age of thirteen in the left side of the face, following a cold. Six months later she remarked, on arising in the morning, that the left side of her face was distorted. From this time on she could not move the left corner of her mouth, nor could she shut the left eye. In spite of treatment with electricity, baths and numerous internal agents, begun within a few days and continued for six years, the paralysis did not change in the least. The girl was otherwise healthy, she came from a healthy family, and in particular no ear or nose disease was demonstrable. Examination showed a complete left-sided paralysis of the face with partial reaction of degeneration and depreciation of the quantitative excitability.

The diagnosis of peripheral facial palsy, of the left half of the face of six years' duration, due to exposure, was made. To overcome it, it was decided to divide the trunk of the left facial nerve and replace its central section by the hypoglossal nerve. For this purpose both nerves were sought through a longitudinal incision which ran from the mastoid process along the anterior margin of the sterno-mastoid to the level of the angle of the jaw. First to expose the facial nerve, the sterno-mastoid was divided at its origin on the mastoid process and displaced downward and backward. Then by proceeding bluntly into the depths with forceps, the trunk of the facial nerve was found in the stylo-mastoid sulcus. It seemed unusually small and had about the diameter of a coarse silk thread, but there could be no doubt as to its identity, for after irritation of the nerve with a weak galvanic current, all the muscles of the left half of the face innervated by the facial nerve began to contract actively.

The section which had been freed up not being sufficient for purposes of anastomosis, a second incision was made obliquely just under the lobule of the ear at right angles to the first and about 3 cm. long, and the facial nerve was exposed to the extent of about 4 or 5 cm. under the parotid, which was retracted forward. In order that it might not slide back again into the depths of the wound during the further course of the operation, it was held up on a blunt hook. The hypoglossal nerve was also found through

the longitudinal incision, in the fork between the external and internal carotids, about at the level of the angle of the jaw, after the digastric muscle had been freed upward somewhat. Under this muscle the nerve could be followed along for about 5 cm. to the point where it subdivided in the hypoglossus muscle. At this point it was cut and turned outward, whereupon certain connective tissue fibers of attachment to the external carotid had to be divided. The stump was long enough so that it could be carried upward to the trunk of the facial nerve without the slightest tension.

The facial now being cut close to the stylo-mastoid foramen, its peripheral stump was united with the central stump of the hypoglossal nerve by two very fine sutures of linen. Finally, the divided muscle and fascia were closed with interrupted catgut and the skin with silk. In order to avoid danger of hematoma, a drainage-tube was introduced through skin and fascia and removed after two days. The wound was healed within a week and left hardly any visible scar behind.

In the first days after the operation the patient could not talk clearly, although the tongue at first could be projected in a straight line. After the third day she showed, on the left side of the face, small elevations and furrows, and on projecting the tongue its tip was definitely directed toward the paralyzed side. While the tonelessness of the speech had disappeared by this time, the patient, even at the time of discharge, fourteen days after operation, experienced difficulty in enunciating several sounds such as g and kl, as she could not bring the tongue up against the palate. Moreover, she had difficulty in enunciating x or chs. The consonants which sounded like s and sz, she could pronounce.

Six weeks after operation, according to general observation, the left corner of the mouth did not droop so much as before. Two and one-half months later, in puckering up the mouth the left half of the upper lip moved slightly and the upper lid showed signs of active depression. Also in blowing up the cheeks, there was no longer any leakage of air such as always occurred before operation. In the course of six months more the left side of the face could be actively moved when the tongue was projected.

In June, 1913, writing in reply to inquiry, the patient said that the left corner of the mouth stood on the same level as the right, and that she could move it a little. The eye, on the other hand, continued to remain open; the speech was still somewhat impeded.

ANASTOMOSIS OF THE SPINAL ACCESSORY WITH THE FACIAL, AND OF THE DESCENDENS HYPOGLOSSI WITH THE PERIPHERAL END OF THE SPINAL ACCESSORY (GRANT'S OPERATION)

An operation originated by W. W. Grant* based upon the employment of the spinal accessory has been performed several times in America with good results. It consists in an anastomosis of the spinal accessory with the peripheral stump of the facial nerve and an implantation of the descendens hypoglossi into the peripheral stump of the spinal accessory. The advantages claimed are that no hemiatrophy of the tongue occurs such as is to be expected after division of the hypoglossus; that during the period of disassociation the paralysis resulting from the division of the spinal accessory is less noticeable and less objectionable than that after division of the hypoglossus; that the disassociation may theoretically at least, be supposed to disappear more rapidly in the sternomastoid and the trapezius muscles than in the tongue, which represents a much more highly organized degree of co-ordination; and that if the graft is unsuccessful, the additional paralysis which results is far less objectionable with the spinal accessory than with hypoglossus.

The following case † illustrates the technique and results:

A young woman of twenty-eight suffered a complete right facial paralysis as the result of section of the right facial nerve during the course of an operation for acute mastoiditis in April, 1911. Two and one-half months later the right face was paralyzed and showed no response in either nerve or muscle to the Faradic current. In spite of careful and continued treatment by a competent neurologist, she was unable to close the right eye or to wrinkle the right side of the forehead (Fig. 449). Operation having been advised, it was performed July 6, 1911 (Dr. Crandon and Dr. Ehrenfried).

A linear incision three and one-half inches long was made along the anterior margin of the sterno-mastoid muscle, beginning at the tip of the mastoid; from the upper end of the wound a crescentic incision was carried forward below the lobe of the ear to a point in front of the middle of the tragus. The posterior border of the parotid was displaced upward and forward by blunt dissection and

* Journal American Medical Association, 1910, Vol. LV, p. 1138.

† See Crandon, Medical and Surgical Reports, Boston City Hospital, Sixteenth Series, 1913, p. 190.

the facial nerve was found where it enters the gland. It was freed up to the point where it emerges from the stylomastoid foramen and was held out of the way by a loop of silk.

The spinal accessory was then located behind the sterno-mastoid muscle and followed down to the point where it enters the muscle just below the level of the lower margin of the jaw. A silk loop was passed about this also. To expose the hypoglossal nerve, the

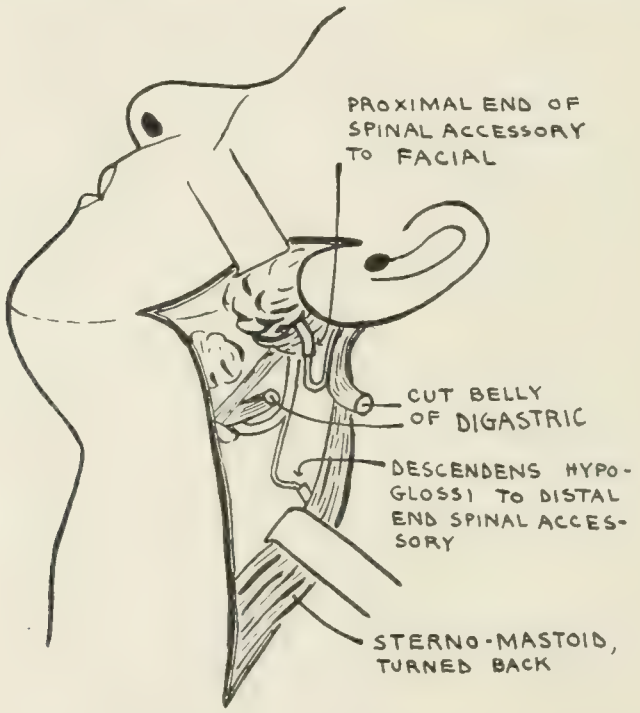


FIG. 449

Diagram of accessory-facial anastomosis and descendens-accessory compensation, Grant's method. (From Boston City Hosp. Med. and Surg. Reports, Series XVI, 1913.)

posterior belly of the digastric was cut at about its middle and the ends turned aside. Beneath it the nerve was found resting upon the hyoglossus muscle. The descendens branch was then easily found and dissected free down along the carotid sheath for about an inch and held up by a loop.

The facial nerve was now cut at the stylomastoid foramen and the peripheral stump pulled outward. The spinal accessory was next divided about one-fourth inch from its point of entry into the sterno-mastoid muscle and its proximal stump was united to the distal stump of the facial by three very fine Pagenstecher sutures,

the first going through the nerves in order to give strength to the union, but the other two going through the nerve sheath only in a plane at right angles to that of the first stitch. The dissection had been so free that even with the head turned far to the left, there was no tension on the line of suture.

By a similar technique the proximal end of the descendens hypoglossi was united to the distal end of the spinal accessory (Fig. 450). There was almost no bleeding. The deep fascia was sewed with No. 1 chromic catgut and the skin with intracuticular silkworm gut; a small rubber drain was left in for twenty-four hours.

FIG. 450

Before operation, right side of face paralyzed, right eye can be only partially closed. (Crandon, Boston City Hospital. Med. and Surg. Rep.)

A dry dressing and bandage were applied, and the head was fixed to prevent turning for the first four days by sand bags.

The convalescence was uneventful. The patient declared she could control liquid in the affected cheek within twenty-four hours, but except for that, practically no change was seen till nearly the end of four months. In the meantime she had been having the galvanic current and massage applied to the region three times a week, under the direction of Dr. Coriat. After the first month the Faradic current was used part of the time. At that time there was present slight motion of right face; no lachrymation of right eye; no reaction of right side of face to strong F. (Faradism); to G. (Galvanism) very slow reaction; complete reaction of degeneration. At the end of four months the girl could hold her mouth straight

for an instant, but always associated with shoulder movement. She could partly close the affected eye.

January 1, 1912. (Six months after operation.) Almost perfect motion right side of face, can close right eye and draw angle of mouth to right. Unable to wrinkle right side of forehead.

January 21, 1912, right side of face reacts only to strong F.; to G. slow reaction; complete R. D. No atrophy of tongue. Able to wrinkle slightly right side of forehead and also can pull voluntarily angle of mouth to right, but all these movements are weak. At rest, right naso-labial fold is prominent. Very slight weakness

FIG. 451

After operation, face symmetrical, right side functions practically as well as left, right eye closes completely. (Crandon, Boston City Hospital Med. and Surg. Rep.)

of right shoulder; able to close eye almost completely. No shoulder drop.

March 10, 1912. (Nine months after operation.) Able to wrinkle slightly right side of forehead; can close right eye completely, but the muscular power is weak. Can draw right corner of mouth upward with fair strength.

July 3, 1912. (One year after operation.) Can close right eye and wrinkle side of forehead to a certain extent. Nearly all movements of mouth muscles present. Muscles react to moderate strength F., to G. quick reaction; R. D. has disappeared.

January 6, 1913. (Eighteen months after operation.) There remains only a look about the face suggestive of asymmetry, but the functions of the eyelid, the cheek and the muscles about the

mouth are practically perfect (Fig. 451). The shoulder and the neck movements are normal. At rest, the right naso-labial fold is less prominent than the left, but the fold is present. Very slight movement of right side of forehead. Can close right eye almost completely, but the movement against resistance is weaker than on the left. No shoulder drop. Movements of tongue normal, no atrophy. On drawing angle of mouth to right, there results a slight shrug of the right shoulder (incomplete dissociation). Sense of taste normal and no subjective dryness of mucous membrane on right. The muscles supplied by the facial nerve on the right react to a moderate Faradic current with almost as active a reaction as the normal side to the same current, but somewhat more sluggishly. The flatness of the right side of the face is due to an overaction of the strong muscles on the left over the weaker muscles on the right.

From these observations, as well as the cases which occur in the literature, it will be seen that anastomosis of the facial with other motor nerves, while occasionally satisfactory, does not usually fulfill entirely the expectations. Kennedy* goes so far as to state that "In no case has a perfect recovery in the movements of the face been proved to take place." Although some of the failures may be explained by an imperfect technique or an improper after-treatment, these criticisms cannot be applied in a large series of cases. Nevertheless, the operation has failed in a considerable proportion. When we consider that with division of the supply nerve, new disturbances of mobility either of the tongue or of the arm are added to the paralysis which already exists, there seems to be ground for seeking new methods which are not combined with this danger. Several have been conceived, and although experience has been too limited to allow of final conclusions, nevertheless they will be introduced here and a few cases cited.

MYOPLASTIC METHODS

According to Jianu,† Gomoiu proposed, in the cases in which after anastomosis not even the tone of the facial musculature returned and the droop of the affected angle of the mouth remained permanent, to overcome this most disagreeable disfigurement, and

* Philosophic Transactions, Royal Society, London, 1911, ccii, 93.
† Deuts. Zeits. f. Chir., Vol. 102, 1909.

at the same time the drooling of saliva, by the subcutaneous implantation of a muscle flap into the angle of the mouth. Through an incision running behind and parallel to the ramus of the jaw, he splits a long strip of muscle from the belly of the sterno-mastoid, preserving, as far as possible, its origin at the mastoid process, on account of the nutrient vessels and nerves. The freed up muscle flap, attached above to the rest of the muscle, is run through a subcutaneous tunnel reaching to the corner of the mouth, and united by subcutaneous suture with the commissure of the lips. Jianu, who likewise employed this technique after extirpation of a parotid tumor, extols the good results as regards elevation of the corner of the mouth. At the same time the deep hole left by the extirpation of the parotid gland is filled in to some extent by the displaced muscle.

Hildebrand, in 1913, showed a girl at the Congress of Surgeons, in whom a marked improvement had been obtained by a similar muscle plastic. The disadvantage of the technique lies in the fact that the corner of the mouth is distorted with every movement of the head, just as, after implantation of the spinal accessory or of the hypoglossal nerve, associated movements occur on lifting the arm or protruding the tongue. For that reason Jianu devised another myoplastic operation to overcome the droop of the corner of the mouth, in which this drawback might be avoided. He employed the masseter in place of the sterno-mastoid muscle. Through a right-angled incision just in front of the angle of the jaw, he came down upon its anterior margin and split off a muscle flap in connection with the periosteum into which it inserts on the jaw, and with its pedicle above. He divided its free lower end in the middle longitudinally for a short distance, and sutured one end of the muscle flap into the portion of the commissure belonging to the upper lip, the other similarly into the lower lip. After a first intention healing, the result was that both corners of the mouth were at the same level.

Lexer* had previously attempted to elevate the corner of the mouth by a similar plastic of the upper and lower lips. He made a skin incision somewhat behind the naso-labial fold, for the scar in this place corresponds to a fold, which is peculiar to many persons. Here also the muscle flap, with its pedicle above, was split away from the masseter muscle, and the free end was divided, to

* Deuts. med. Woch., 1908, No. 23, p. 1038.

be sewed into the commissure of the lip above and below. The result showed particularly that the lower lip was elevated and that on moving the jaw the lips could be pressed together, so that on drinking no fluids ran from the corner of the mouth.

The lagophthalmus which occurs as the result of facial paresis has always been an indication for surgical treatment, to a greater degree even than the droop of the mouth. Since paralysis of the lower lid always results, in the course of time, in the formation of an ectropion, operators were formerly satisfied to bring the pro-

FIG. 452
Left-sided facial paralysis.

jecting lower lid back in apposition to the bulb by tarsorrhaphy or by blepharoplasty. In this way the punctum lacrimalium was restored to its proper relation to the bulb, and the width of the palpebral fissure was diminished, but active closure of the lids was not obtained. To attain this at the same time with correction of the ectropion, Krause, in analogy to the masseter plastic at the corner of the mouth, formed a flap from the temporal muscle and planted it subcutaneously behind the outer canthus into the lower lid.

The following case shows how myoplastic elevation of the lower lid and of the corner of the mouth is performed.

A fifty-two-year-old civil officer had had for ten years a facial

palsy of the left side which remained unchanged in spite of long-continued treatment (Fig. 452). The chief difficulty experienced by the patient was referred to the completely paralyzed lower lid, the upper lid preserving a minimum of its ability to close. However, it did not seem clear whether this did not come as the result of atrophy of the levator palpebræ superioris, which is supplied by the motor oculi nerve. The lower lid hung down completely lax and stood away from the eyeball motionless in a condition of ectropion, so that the tears continually dropped off over the margin, greatly to the discomfort of the patient. A complete paralysis of the corner of the mouth also caused difficulty; as a high magistrate, his ability to talk was interfered with by the drooping and incomplete closure of the mouth. For that reason he desired to be relieved of these particularly distressing results of left-sided facial paralysis.

Nerve anastomosis was not considered in this case, as enunciation might be still more impeded after division of the hypoglossal, as the result of the unilateral paralysis and atrophy of the tongue. Likewise implantation of the spinal accessory had to be rejected as the associated movements of the shoulder and arm, which could not be avoided in the first months at least, would cause further distress to an official in his position, particularly in view of the fact that complete dissociation cannot always be assured. For that reason a myoplastic operation for the relief of the droop of the mouth as well as the ectropion was decided upon. The scars did not have to be considered in this case, as the affected side of the face was already covered in considerable number by sword cuts. Accordingly a myoplasty for the relief of the droop of the mouth was begun, according to the methods of Lexer and Jianu.

The cheek was split vertically over the anterior margin of the masseter muscle, whereupon the facial artery was exposed, double tied, and divided (Fig. 453, Plate 79). The muscle in this case, particularly in its anterior portion, was surprisingly poorly developed, but nevertheless, after removal of the fat of the cheek, a surface several centimeters wide could be exposed (Fig. 454, Plate 79). On account of this atrophy, the cutting out of the plastic muscle flap at the margin of the jaw in connection with the periosteum was given up, and a larger portion of about half of the masseter was separated (Fig. 455, Plate 79). In order to free the corner of the mouth where the tip of the flap was to be

Masseter plastic for elevation of the angle of the mouth, after E. Lexer and Jianu.

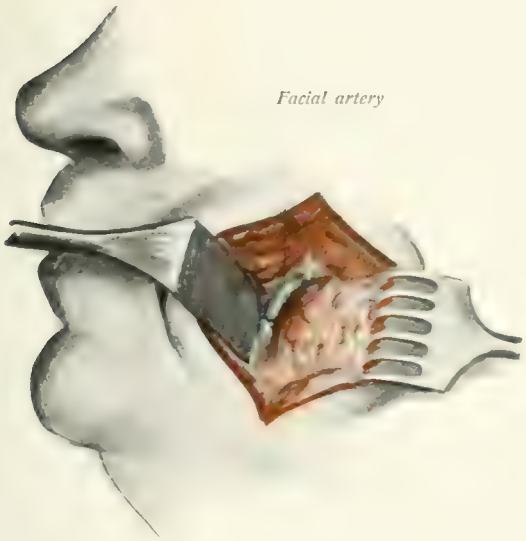


Fig. 453. Skin incision over the anterior edge of the masseter muscle.

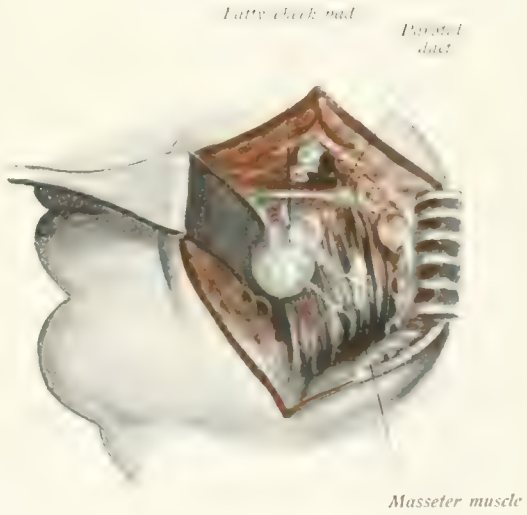


Fig. 454. Exposure of the masseter muscle.

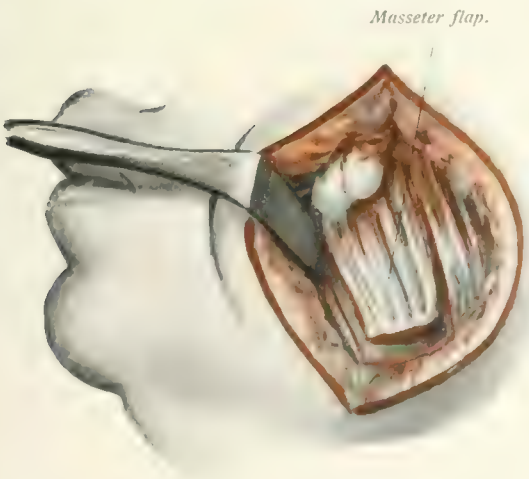


Fig. 455. Forming the plastic flap from the masseter muscle.

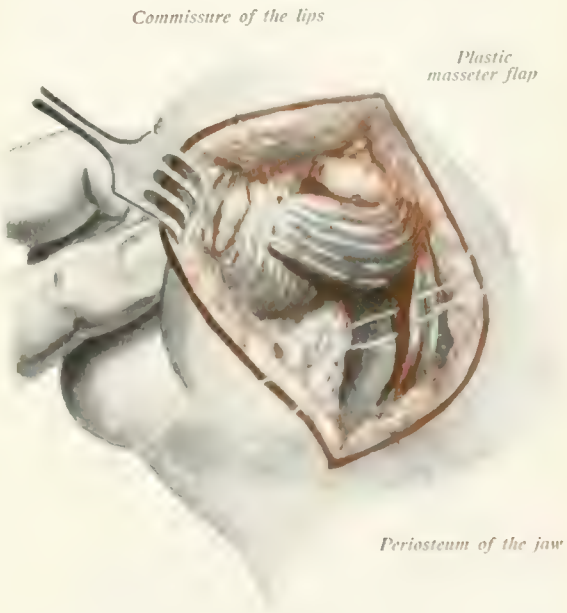


Fig. 456. The commissure of the lips is pressed by the finger within the mouth, and the muscle suture completed.

Temporal plastic for correction of paralytic lagophthalmus after F. Krause.

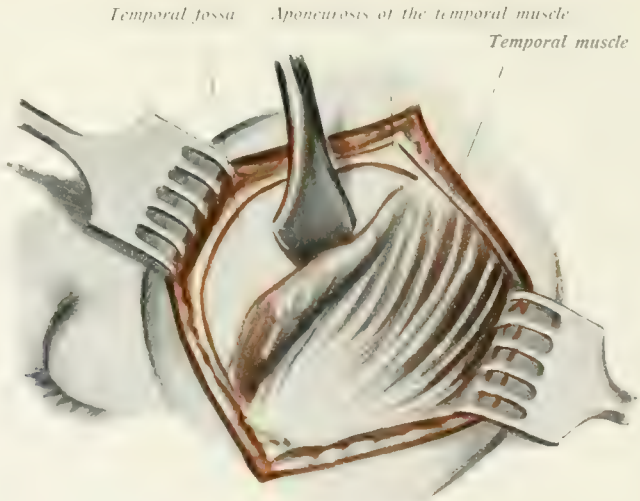


Fig. 457. Incision along the anterior margin of the temporal muscle.

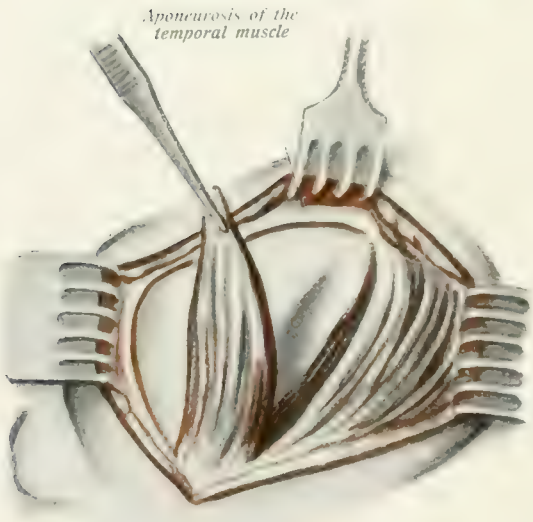


Fig. 458. Formation of a muscle flap from the temporal muscle.

Fig. 459. The incision is lengthened along the zygoma and the lower margin of the orbit.

Fig. 460. The temporal flap is sewed into the lower lid.

Fig. 461. The defect is made smaller by drawing together the wound edges.

implanted from superfluous tissue, the left index finger was inserted into the mouth (Fig. 456, Plate 79), and under its guidance the skin of the face was separated from the mucous membrane of the cheek with scissors, as far as the commissure of the lips.

Next the flap of the masseter was carried upward at a right angle without twisting, until it could be sutured without tension into the left corner of the mouth by means of three interrupted catgut sutures. At this point the advantage of freeing up some of the periosteum of the lower jaw in connection with the muscle flap was very evident, as the stitches held much more securely in the periosteum than would have been possible in the muscle belly. In order to definitely obtain an elevation of the corner of the mouth, the tip of the muscle flap was united particularly to the portion of the commissure belonging to the lower lip. To split the flap and to unite the upper half to the upper lip and the lower to the lower lip, as carried out by Lexer, seemed to be of no advantage in this case on account of the atrophy of the muscle. Then the wound margin in the masseter muscle was united by three interrupted catgut sutures to the remaining periosteum of the jaw, and the defect in the muscle largely closed, by which means the separated plastic flap, as well as the corner of the mouth, was given further support. Finally, the fascia and skin of the cheek were closed carefully without drainage.

Following the same principles a muscle plastic according to Krause for the correction of paralytic lagophthalmus was carried out. The incision ran from the middle of the upper margin of the zygoma obliquely upward and divided at once the temporal fascia, exposing the fibers of the temporal muscle. In forming a plastic flap from this muscle, it is to be borne in mind that it increases in thickness from above downward, and it inserts by means of a tendon below the zygoma into the coronoid process and, moreover, it receives its vascular and nerve supply from below. Accordingly, as a well-nourished functionally active muscle flap must maintain its base below, the temporal muscle was exposed only above the zygoma and starting from its upper margin, a quadrilateral flap with a pedicle below was cut out. The anterior margin of the flap was made at the edge of the aponeurosis (Fig. 457, Plate 80), the posterior, after the required section of muscle was freed up from the underlying layers by a blunt dissector (Fig. 458, Plate 80), in the muscle belly itself. In freeing up

the plastic flap, particular care was taken that its connections were nowhere injured, and that its delicate sheath was not torn.

To allow of the implantation of the free end into the lower lid and the external commissure, the incision had to be continued forward at right angles in the fold of the lower lid (Fig. 459, Plate 80). In freeing up the newly made wound edges no fibers of the orbicularis palpebrarum were to be found, but instead only the tarso-orbital fascia. Accordingly to this the muscle flap was united with the finest catgut, after it was turned into the defect in such manner that what was originally its under side, lying upon the temporal bone, was directed toward the orbit (Fig. 460, Plate 80). The immediate result of this implantation was that the lower lid was put under tension and elevated. The ciliary margin was still somewhat everted at the outer canthus of the eye, which was remedied at once by uniting the medial bands of the outer commissure to the upper margin of the transplanted flap by means of one suture (Fig. 461, Plate 80). Finally the temporal fascia was drawn together, so far as possible, by three interrupted catgut sutures, and the skin was carefully sutured with silk.

Two months after operation the patient, and his wife as well, stated decisively that the condition was an extreme improvement over his former state. When talking in public he could be better understood by a large audience on account of his much clearer enunciation. The inner half of the left lower lid, with the punctum lacrimalium, lay completely in apposition to the bulb; the outer half still stood away slightly, but much less than before the operation. Here in the tiny sac tears still gathered at times, particularly if inflammation of the conjunctiva was present, but they did not, as formerly, run down over the cheek. On opening the mouth the lower lid was placed under tension and drawn slightly to the left, and the projection of the outer half from the bulb was likewise diminished.

The position of the mouth was also improved over the original condition. Saliva no longer flowed from the left corner of the mouth, which, to be sure, still drooped somewhat, but much less than formerly. The mouth could be puckered up, not as in a normal person, but better than before. The patient remarked also that the corner of the mouth had lately drawn up still further and that, accordingly, he could be better understood when talking. There was hope that the muscle bundle, which was weakened at first by the

operation, would gradually become stronger through use, and the final result, accordingly, was to be expected only after considerable time.

MECHANICAL ELEVATION OF THE PARALYZED CORNER OF THE MOUTH

In addition to nerve implantation and muscle plastics, there is still another technique, easily carried out, which limits itself to a mechanical elevation of the corner of the mouth paralyzed by facial paresis. It has shown throughout cosmetically favorable results, and on occasion may well find employment as a supplementary operation after unsuccessful nerve or muscle plastic. According to Momberg* Busch originated the technique of carrying an aluminum bronze wire subcutaneously from the periosteum of the zygoma down around the corner of the mouth and tying it to form a sling by which the normal and the paralyzed commissures would be brought to stand at the same level. Momberg has performed this operation five times with favorable results. His modification is as follows:

Two small horizontal incisions are made, one above the zygoma going down to bone, and the other through the upper lip above the commissure. Then a straight needle, with a large eye in which is threaded a fine aluminum bronze wire, is carried subcutaneously through from the upper wound in the cheek to the lower wound, and from this point it is carried back again to the upper so that the wire surrounds the zygoma. Then the wire is tightened until the angle of the mouth is brought to the same level as on the normal side; the wire is tied, and the knot buried. Momberg makes a particular point of the disadvantage of local anesthesia in this otherwise slight operation for, as the result of infiltration, judgment concerning the amount of overcorrection which at first is necessary is rendered difficult.

Stein proceeds in a similar manner, only he employs in place of wire a strip of fascia 20 cm. long and 2 cm. wide dissected out of the fascia lata, and carried from the region of the zygoma through the cheek down to the paralyzed corner of the mouth. He remarks, especially, the good cosmetic result and also the favorable psychic influence which this simple procedure affords in a patient with mouth droop.

In estimating the value of these various methods, it must be

* Berlin. klin. Wochenschr., 1910, No. 24.

borne in mind that a complete restoration of the usually fine mimic movements, such as normal innervation by the facial nerve would allow, should never be expected. This could only be conceived as possible if, after division of the trunk of the facial, and after healing in of the implanted accessory or hypoglossal nerve, a primary union of all the nerve fibrils should take place or a complete formation of new fibers in the old track, such as, for instance, is attempted by the tubulization method of Vaulaire. So fortunate a result is theoretically most improbable, at least so long as we maintain the theory of neurones and the projection of every single end organ in the cortex. Accordingly, with the gross expedients with which the surgeon is forced to labor, and with regard to the fact that we have to do ordinarily with diseased nerve tracks or with paralyzed muscle, a complete restoration of normal conditions is still less to be expected.

What we desire to attain by the various methods and what it is alone possible for us to obtain is, therefore, not the restoration of the innumerable finely differentiated motor paths of the facial nerve, but the correction of the most important disturbances induced by the paralysis which not only disfigure the patient externally, but also cause him serious hardships from the social point of view. The single movements which are employed in talking, laughing, crying and other psychic expressions do not return, but the general muscular tone is recovered, and in more favorable cases, at least, active movements on the paralyzed side, so that in rest the corner of the mouth no longer droops, but stands at the same level with the other side. The loss of apposition of the lower lid to the eyeball, with its disfiguring lagophthalmus and its serious possibilities for the eye, is also in large part overcome.

OPERATIONS FOR TIC DOULOUREUX

In the distribution of the facial nerve clonic and tonic cramps occur which are called convulsive tic. If, as is commonly the case, other forms of treatment do not succeed, surgical procedures are to be considered. By means of comparatively insignificant operations many cases of this occasionally exceedingly painful disease may be improved or cured. The more preferable of these are stretching of the nerve, and resection of the branch of the trifacial in which the impulse occurs.

For stretching of the facial nerve, the trunk can best be found

through an incision at the posterior margin of the ascending ramus of the jaw. The ramus colli, the marginal mandibular ramus or one of their branches is found, and in the direction of their course a second incision is made behind the mastoid process; by following up one of these branches, the facial nerve is reached. During the stretching which now follows, one can test to see if the entire trunk has been seized; for the cramps, which continue under light anesthesia, cease immediately as soon as the supplying nerve has been stretched. If, therefore, contractions are still visible in any region after stretching, one can infer that the affected branch has not been stretched sufficiently. In order to be certain of the result, the stretching must be continued until paralysis sets in. This is apt to disappear after an all too short a time, for most patients prefer complete paralysis to the former distressing condition. However, one cannot cure all cases by this method, particularly those in which we must infer a central cause which affects the nucleus of the nerve itself.

In such cases and in difficult ones which are not affected by other means, it seems justifiable if the symptoms demand it to divide the facial nerve and to implant the hypoglossal or accessory nerve end to end into its peripheral stump in the manner above described. The outlook for primary union of the divided nerve fibers, exactly fitted to each other, is particularly favorable, as it is a case of fresh aseptic wound surfaces. This physiologically should be the right way to get permanent relief in severe cramps arising from a central cause: by this means the irritated facial nucleus is isolated and replaced by the normally functionating hypoglossal or spinal accessory nucleus.

OCCIPITAL NEURALGIA

In trifacial neuralgia, cases are not infrequent in which several trunks or branches are affected sympathetically. We find this peculiarity present and in a far greater degree in severe cases of occipital neuralgia (also called cervico-occipital neuralgia), a circumstance which makes it often impossible to determine exactly the nerve distribution primarily affected. The nerves which are principally concerned are the great occipital, the lesser and third occipital and the great auricular; less frequently the cutaneous cervical nerve and the supraclavicular nerves come under consideration (see Figs. 462 and 469).

The area ordinarily affected by the neuralgia (Fig. 462) corresponds to the distribution of these four nerves, and accordingly includes one side of the occipital region, the lateral section of the skull forward as far as the external ear, the region of the lower jaw, particularly in the posterior section corresponding to the artic-

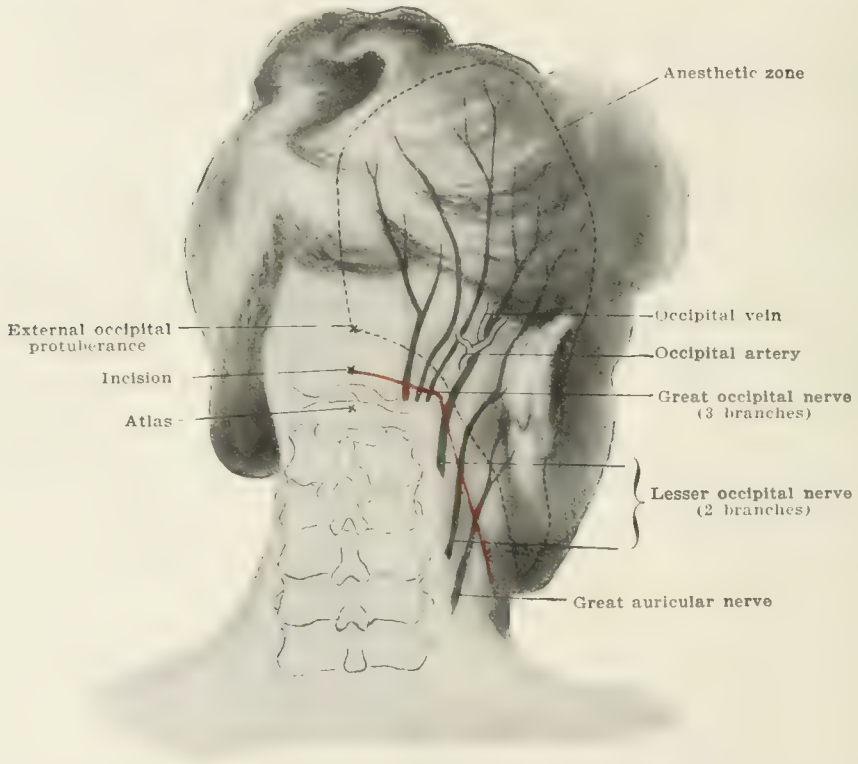


FIG. 462

Thirty-three-year-old patient, photographed sixteen days after operation. The fresh scar showed so poorly that it is marked in red. The bony outlines and the nerves have been drawn in, and the occipital vein and artery at the point where they become superficial. The zone of anesthesia is shown as it appeared nine days after resection of the nerves.

ulation of the jaw, and finally the upper portion of the neck down to about the level of the hyoid bone.

The type of pain and the causes which occasion it agree generally with those of trifacial neuralgia. Any movement of the head, particularly bowing, may set up an attack; there exists increased sensibility to smell, motion, and to light. Psychic excitation may also start up attacks.

The severity of the pain is no less than that of severe trifacial neuralgia; and in the same way the phenomenon of eradiation

occurs. The pain involves the entire neck and occipital region; it radiates as far as the clavicle and the shoulder, and on to the lower jaw as far as the chin; the articulation of the jaw may also be painful. On occasions the attacks are accompanied by spasmodic contractures of the muscles, which rotate the head, hold it rigid to one side, or pull it backward; and the facial muscles are also involved at times. At the height of the attack there is dizziness, nausea, and vomiting. Of vasomotor manifestations, there are observed reddening of the ear and of the skin covering the back of the neck, and a flow of tears from the eye of the affected side.

The points which are characteristically painful to pressure have their location in the places where the nerves come up out of the depths and can be reached by the finger; the great occipital at the place where it penetrates the trapezius muscle and becomes subcutaneous, that is to say about half-way between the mastoid and the second vertebra, or two or three cm. lateral to the external occipital protuberance. The pressure point of the lesser occipital is somewhat further external, and lower down, at the posterior margin of the mastoid; of the great auricular at the posterior margin of the sterno-mastoid about at its middle, on the level of the hyoid or just below.

In the diagnosis of occipital neuralgia there must first be ruled out caries of the upper cervical spine, in which a severe neuralgia, which is sometimes bilateral, often arises as the result of irritation of the nerve roots. Similar manifestations may appear in arthritis deformans of the upper cervical articulations. Examination must also be made for diseases of the ears; of these, sclerosis of the cortex of the mastoid, particularly, causes severe and lasting pain. Of particular assistance in ruling out bone diseases is the fact that neuralgia, even after many years' duration, never shows any changes outside of slight trophic disturbances, redness, swelling, and thickening of the skin, in addition to the increased sensibility.

Operative treatment is shown in the following case:

OCCIPITAL NEURALGIA AND SPASM OF THE ACCESSORY NERVE

A woman forty-one years old, whose history showed nothing of note, remarked in 1912 that her head was twisted involuntarily to the left, so that the occipital region was pulled spasmodically over onto the right shoulder. In addition, since the 18th of October attacks of right-sided headache had occurred. From that date the

muscle contractions decreased somewhat, but the clonic twisting of the head continued and made it impossible for the patient to lie in bed.

Examination showed the chin turned to the left, as a result of contraction of the right sterno-mastoid and trapezius muscles, and the head bent over on the right shoulder. At times both muscles were lax while the head was held in this position, showing that still other muscles were involved. Pressure on the bones in the occipital region and upon the cervical spine was not painful, except over the points of exit of the great occipital nerve. The patient was only to a slight degree able to overcome this condition of contracture; in attempting to correct the deformity passively, one could feel a strong elastic resistance, and the pains increased. The sensibility in the regions of the occipital and the supraclavicular nerves was preserved. The diagnosis of spasmodic contraction in the distribution of the right accessory nerve with involvement of sterno-mastoid and trapezius muscles and neuralgia was made.

As all other methods of treatment had been without avail, operations were undertaken on November 7, 1912.

The patient lay upon the normal side; the head was held so that it could be brought into any required position. Incision through the thickened skin (see Fig. 463) began in the occipital region near the median line about 3 cm. below the external occipital protuberance; it ran practically horizontal in the direction of the tip of the mastoid process to within 2 cm., and then turned obliquely forward and downward along the posterior margin of the sterno-mastoid about 7 cm., and ended just below the level of the hyoid bone. Except for a small portion of its length, the incision ran within the hairy scalp.

After completion of the incision the upper margin of the wound was carefully dissected up with a knife in order to come down upon the branches of the nerve (Fig. 464, Plate 81). The great occipital nerve first came into view about 3 cm. from the middle line. Near by, externally, a branch of the occipital artery was seen, which did not have to be tied. At the outer margin of the incision lay the great auricular nerve, which for the time being was not disturbed. In order to expose a nerve which ran medially near the great occipital, the inner margin of the trapezius muscle had to be nicked. The nerve trunk itself penetrated the trapezius muscle from the depths on a level about 1½ cm. below the external occipital

Resection of the occipital and posterior cervical nerves.

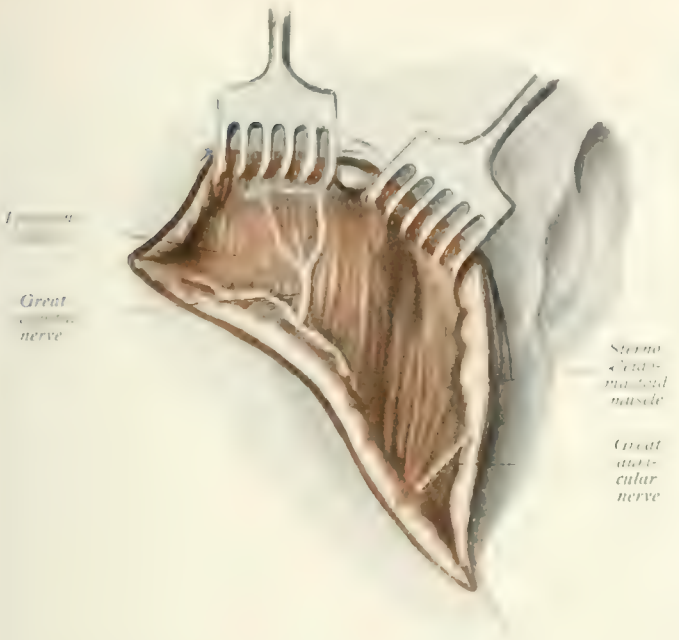


Fig. 464. Superficial exposure of the great occipital and the great auricular nerves.

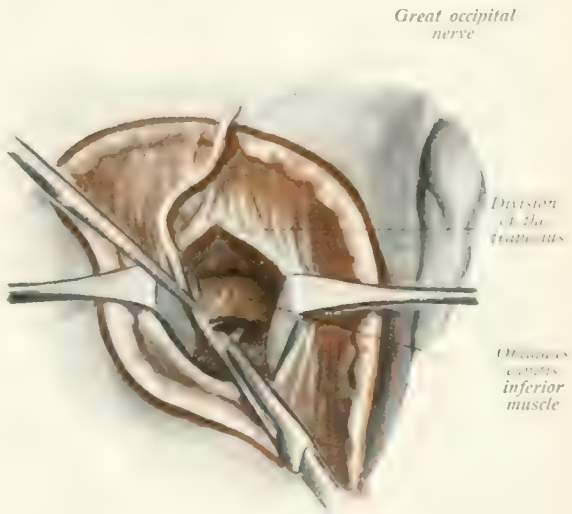


Fig. 465. Following the great occipital nerve into the depths.

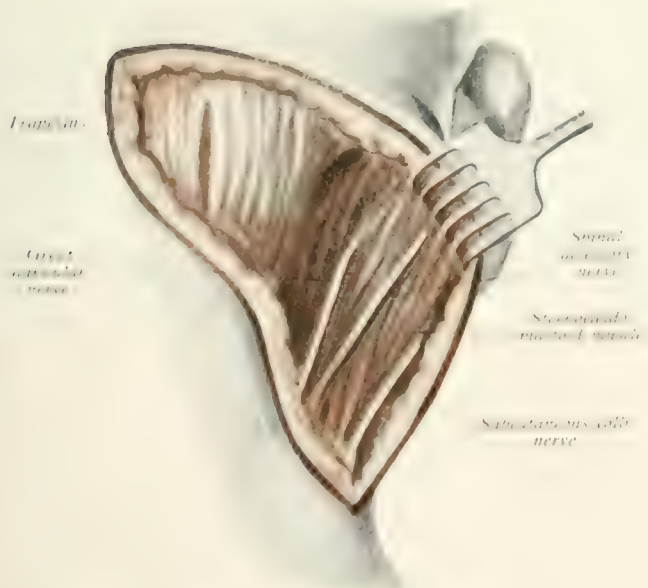


Fig. 466. Exposure of the great auricular nerve, and the lateral nerves of the neck.

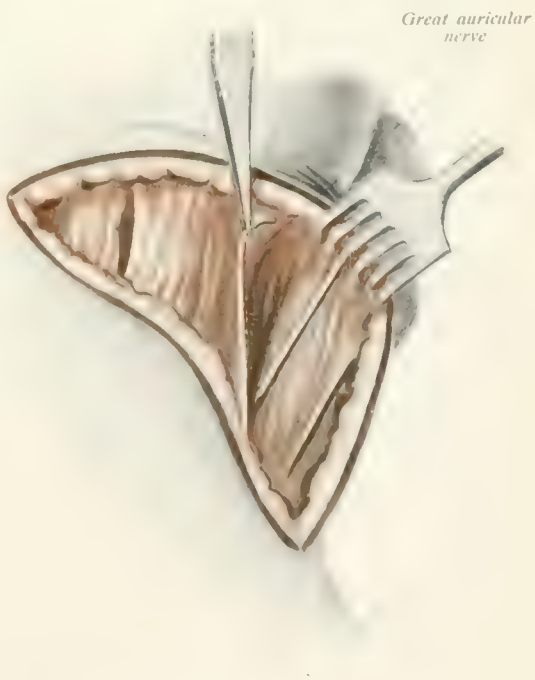


Fig. 467. Resection of the great auricular nerve.

protuberance. Since in this patient the area of pain corresponded solely to the distribution of the occipital nerve, this was dissected from the musculature in the depths.

In this process the occipital artery came into view and was retracted outward; only one branch had to be tied. In the depths two other small branches were given off by the nerve trunk, one upward to the right and the other medially (Fig. 465, Plate 81).

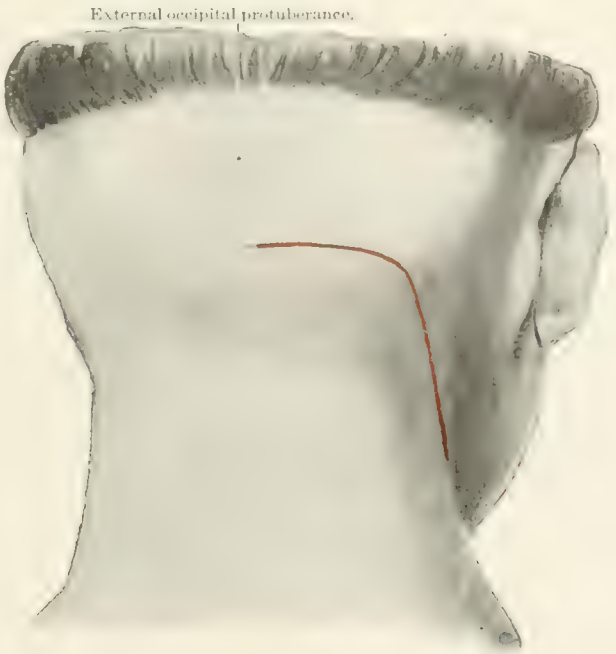


FIG. 463
Incision in occipital neuralgia.

Externally the deepest neck muscles came into view (obliquus and rectus capitis).

In order to be able to continue the dissection to the required extent, the peripheral nerve branches at the upper margin of the wound, which constituted a hindrance, were seized with nerve forceps and twisted out. The nerve trunk was then seized between the deep muscles of the neck and pulled up forcibly. Obliquely below the nerve ran a large vein, which was avoided and could be displaced downward by blunt dissection.

Since the great occipital nerve in its deeper course may be surrounded by portions of the posterior cervical venous plexus, which is in communication with the occipital vein, one proceeds here so far

as possible with blunt instruments. Venous hemorrhage at such depths are much more disturbing than arterial, and can be controlled only by compression. The deep and narrow wound must be held apart by strong retraction, using hip-joint retractors; the pressure and pull of the retractors stop the bleeding in case it is not too severe. Centrally to its branches, the nerve was seized deeper and deeper with forceps, and was pulled out until it was finally divided away in the depths, and its peripheral branches could

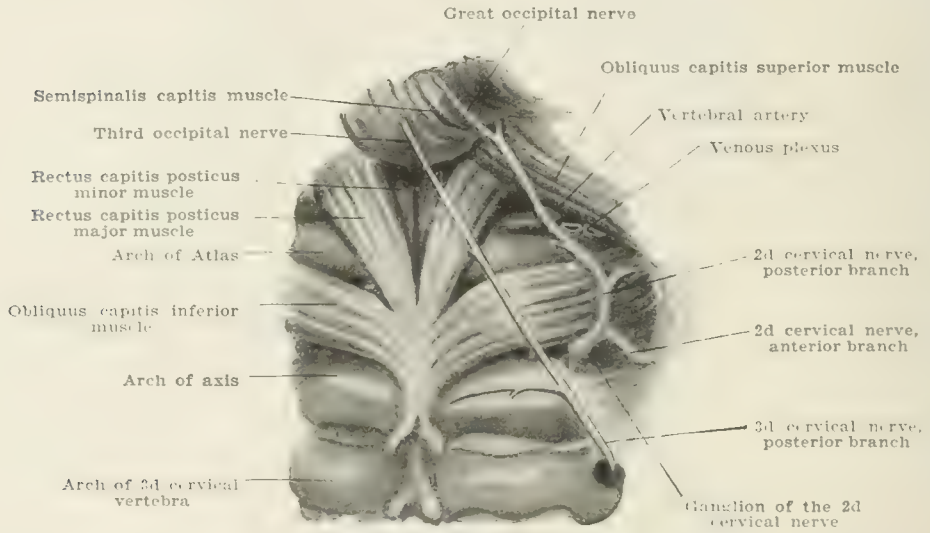


FIG. 468

Dissection of the deepest layers, about natural size; seen from behind. The semispinalis capitis has been divided and its upper portion turned upward. The great occipital and third occipital nerves are seen entering it. The great occipital has been displaced slightly to the right. The right obliquus capitis inferior muscle is displaced slightly upward, so as to render visible the ganglion of the second cervical nerve.

(The posterior branch of the first cervical nerve passes above the posterior arch of the atlas and below the vertebral artery just at the point occupied in this picture by the displaced great occipital nerve. As it gives off no branches to the skin it has no significance for our purposes, and is not shown.)

then slowly be twisted out. As all the vessels were shoved to one side or tied there was no bleeding.

The anatomical relations, which are complicated, are shown in the dissection pictured in Fig. 468.

In following up the great occipital nerve we find that after penetrating the semi-spinalis capitis, it rests upon the deepest layer of muscle, that is to say upon the posterior surface of the rectus capitis posticus major, and adjacent to it the corresponding surface of the

obliquus capitis inferior. It crosses both muscles at right angles to the direction of their fibers. Finally the nerve running outward curves around the posterior edge of the obliquus into the depths, and in this course represents the entire posterior root of the second cervical nerve. Here it joins the anterior root, to form the trunk of the second cervical nerve. This differs from all the other spinal nerves in lying outside the spine, and for that very reason its ganglion is approachable through our incision without bony operation. Between the atlas and axis there is no intervertebral foramen, but corresponding to it is a fissure more than a centimeter wide, in whose lateral corner external to the origin of the posterior bow of the atlas, the ganglion is to be found. This lies 3 to 5 mm. from the obturator ligament which closes the space between the atlas and axis. Krause has never extirpated the ganglion in the living, but has limited himself to division of the trunk. Extirpation, as he has shown by numerous investigations on the cadaver, is technically possible, and indeed without injury of the spinal column. He considers that it should be given the same significance as extirpation of the Gasserian ganglion in trifacial neuralgia.

Since the Thiersch method transmits a pull over a considerable distance toward the nerve center before the nerve will yield, this method is not to be used with the cervical nerves. The posterior roots are frequently connected with each other by anastomotic loops, and in the anterior these loops are always present. In addition the phrenic nerve consists completely or predominatingly of the fourth cervical nerve, but often receives fibers from the third as well. The nerves should preferably be dissected out in the manner described and divided as far centrally as possible, by which method all anastomoses with the neighboring nerves are divided at the same time.

Now in the case just cited the distributing branches of the nerve remain to be dissected out. For this purpose, after an obstructing gland under the tip of the mastoid process was removed, the incision was carried down a ways along the posterior margin of the sterno-mastoid until two cutaneous nerves and the accessory nerve, with its posterior external branch (ramus muscularis), were exposed at the muscle edge over an extent of at least 4 cm. (Fig. 466, Plate 81). The spinal accessory was stimulated with a very weak Faradic current, such as is employed on the cortex of the brain, and a strong contraction of the trapezius and sterno-mastoid muscles,

which it supplies, followed. The cutaneous nerves which had also been exposed were the ausicular and the subcutaneous colli. The same current which aroused a strong response in the accessory nerve, when applied intimately to these completely isolated nerves induced no response. The accessory was resected for a finger's length (Fig.

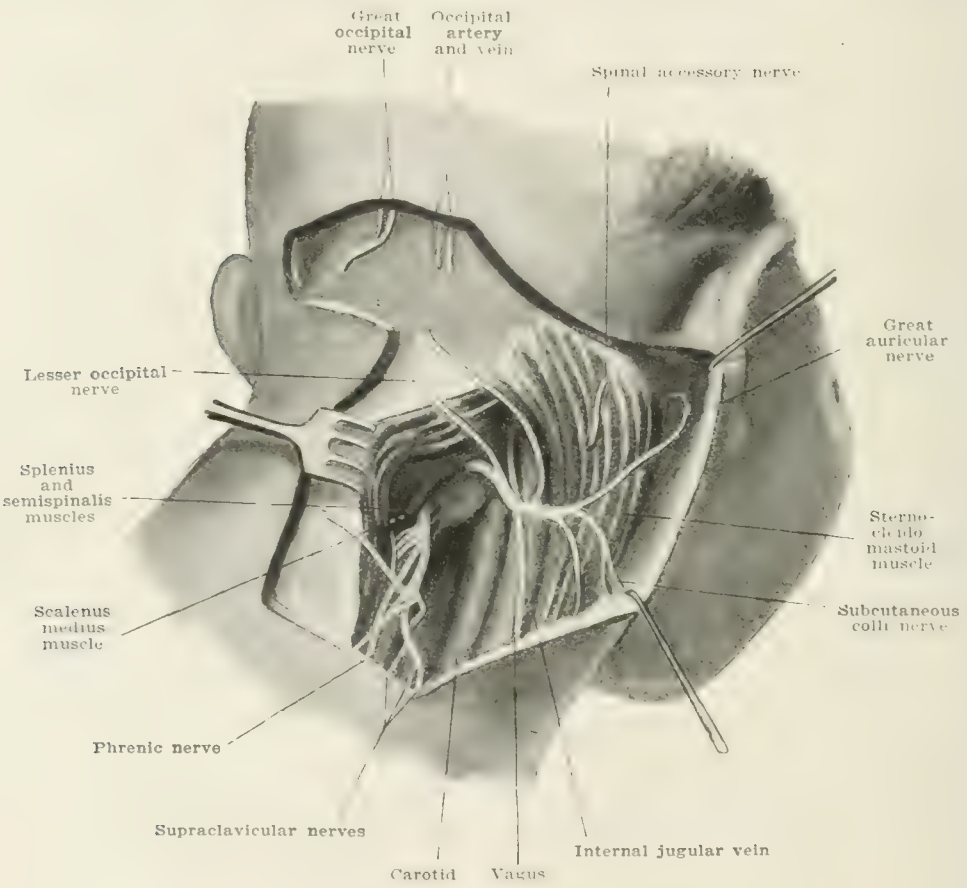


FIG. 469

The anterior branches of the third and fourth cervical nerves, and their relations. The vagus nerve, to render it visible, has been laid upon the jugular vein. The lesser occipital nerve is coming off in two divisions from the third cervical. The spinal accessory has been divided, and its central end turned upward on the sterno-mastoid muscle.

467, Plate 81), and in addition the two cutaneous nerves just described, on account of their involvement in the neuralgia.

The anatomical preparation pictured above (Fig. 469) serves to show the relations.

After completion of the operation, the wound was closed with sutures.

The wound healed normally and without alteration of temperature or pulse. On the eighth day the stitches were removed. The painful spasmodic torticollis persisted in a diminished degree in the first days after operation, but the patient could lie in bed without distress. After the fifth day the patient required no further opiates and the cramps grew less in frequency and severity; on the twelfth day after the operation, at her own desire the patient was allowed

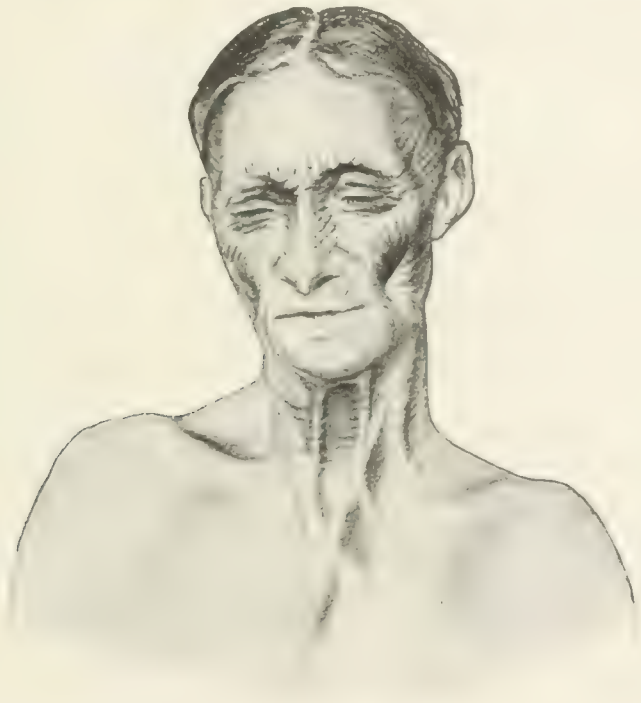


FIG. 470

Spasm of the spinal accessory nerve, in a sixty-four-year-old patient.

to return home, in good subjective condition and with a practically normal position of the head. Later reports were equally favorable.

For the origin of *spasmodic torticollis*, which usually depends upon spasmodic contractions in the distribution of the accessory nerve, irritative conditions in the neighborhood of the affected muscle: scars, tumors, etc., have been found answerable, and at times have shown the way to causal therapy; but often the etiology of this affection is unclear.

Cramps of muscles innervated by the accessory nerve may appear

in the most severe degree and extend far over into the surrounding area. They also give rise to severe pains in the contracted muscle. In a sixty-four-year-old lady, under our observation (Fig. 470), a slight degree of accessory spasm had arisen twenty years before with contractures of the head; gradually as the result of severe misfortune and great mental agitation the severe and intensely painful spasms were transmitted to all the muscles of the body down as far as the abdomen, so that practically only the lower limbs remained uninvolved.

In mild cases the resection of the accessory nerve just described causes alleviation, and even cure; in severe cases the muscles involved must be resected (sterno-mastoid and cervical muscles); but in the severest cases even the most extensive procedures cannot be depended upon to always give a favorable result.

Keen has shown that other muscles may be involved in spasmodic torticollis. In a case reported by him the spasmodic contracture involved the small muscles of the cervical spine which run from the neck to the head. By resecting the affected nerves he obtained improvement.

Isolated spasms in the distribution of the facial nerve, which are mentioned on page 454 f., depend upon causes similar to those in the case of the accessory nerve.

CHAPTER 18—SURGERY OF THE BRAIN

POSTURE AND METHODS OF ANESTHESIA

In all brain operations one should take particular care that no pressure is made on the abdomen or thorax by which the respiration may be obstructed. The level of the table must be readily adjustable, so that in threatening venous hemorrhage it will be possible in a moment to elevate the patient to a more upright position, or in case of collapse to drop the head and upper part of the body.

In operations on the cerebrum, the patient lies flat on his back or the thorax is elevated at an angle a little less than forty-five degrees. In operations on the lateral regions of the skull, the patient lies upon his back or side, with the head solidly disposed on sand bags. In operations upon the cerebellum, it is convenient to have the patient lie facing downward, with the head slightly flexed. To accomplish this without interfering with the freedom of respiration, a frame may be used which has crutch sockets for supporting the shoulders, and some means of supporting the forehead. If this be projected beyond the end of the table, it allows the anesthetist free approach to the patient from below.

For the reasons given in Part One, European operators prefer chloroform to ether, which is generally used in this country. Whichever is employed, it should always be administered by an expert. Harvey Cushing has emphasized the importance of following the patient's pulse and blood-pressure before and during the procedure by observations plotted on a chart, as the best means of gauging the effect of the manipulations, and of anticipating shock. An artificial respiration apparatus should always be at hand, for use in case of respiratory failure from any cause.

However, many cases can readily be carried out under local anesthesia. The general technique for this procedure has already been given, but the following case will show how an osteoplastic decompression was done over the posterior central convolution, a portion of the parietal lobe, and over the temporal region in a fifty-one-year-old woman, by this method.

Without a preliminary hemostatic suture, subcutaneous injection of 2 c.c. of novocain-suprarenin solution was made at each of the four corners of the operative field. Then through the subcutaneous wheals further subcutaneous and subfascial injections were made with a longer needle, outlining the desired flap. Subperiosteal injections, as always, were omitted as useless. After a few moments the incision could be made through the soft parts, whereupon only a few arteries spurted under slight pressure, while venous and parenchymatous bleeding did not occur at all.

OSTEOPLASTIC METHODS OF OPENING THE SKULL

The first to employ the now generally adopted osteoplastic method on human beings was Wagner-Königshütte, although J. Wolff had previously used it in experimental work on animals. The nutrition of the bone and tissue flap is served through a pedicle ordinarily as wide as the flap itself, which is generally placed toward the base of the skull. The incision may be seen in the various pictures in the text and on the plates. This osteoplastic technique is employed in all cases in which an opening is made in the skull, except for rare instances of which we will make special mention. In this technique various methods may be applied, which have been originated in the last few years.

Formerly the chisel and hammer were used exclusively. With these simple instruments an opening of any desired form or extent could be made. Chiseling of the channel had to be carried out with great care and took a long time, and any increase in the duration of the operation increased the loss of blood from the diploë. While generally speaking we no longer make use of the chisel, employing in its stead better methods, in emergencies, in case other instruments are not at hand, it may satisfactorily be employed. In chiseling, the blows of the hammer are directed not perpendicularly, but tangentially, against the skull; in this way the unavoidable vibration, which involves a certain amount of danger to the brain, is decreased.

PROVISIONAL CONTROL OF HEMORRHAGE

In large openings of the cranium, if they are not undertaken under novocain-suprarenin injections, the loss of blood from the soft parts may be considerable, and even dangerous; as a rule, under these circumstances we induce provisional anemia. The placing of a

stout band or tube of elastic around the base of the skull offers no sufficient assurance, and frequently has increased the venous hemorrhage. We prefer to place a suture around the immediate neighborhood of the opening, according to the method of Heidenhain, to shut off the blood supply to the operative field.

Heidenhain * applies a very tightly drawn backstitch, so as to enclose the scalp in a continuous suture on both sides of the intended incision, and allows this to remain in place eight or ten days after the end of the operation, or until the wound stitches

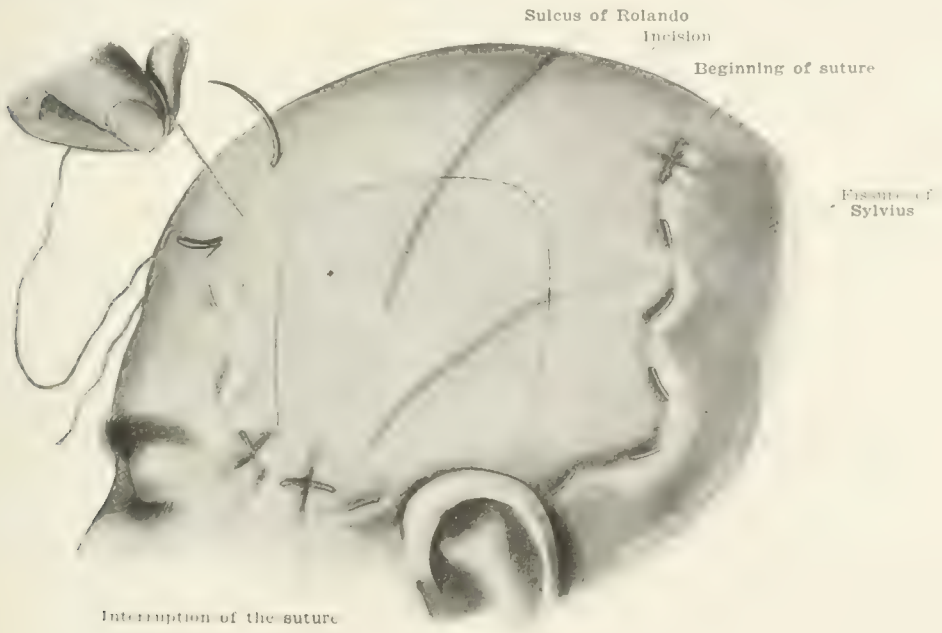


FIG. 471

Applying the hemostatic suture preparatory to making the incision.

are removed. For this suture a half-round medium-sized needle is used, carrying silk of medium size. The needle, so far as possible, should penetrate to and slide along the bone at each insertion.

We apply the continuous backstitch around the planned incision, but only on the proximal sides, and naturally below the base of the flap (Fig. 471). We employ a very strong curved needle and the strongest silk, and even with the largest flaps, as a rule, interrupt the suture only once; that is to say, the suture is completed with two needlefuls of silk. To prevent the needle from meeting and cutting the preceding loop of silk, the backstitch is made by

* Zentral. f. Chir., 1904, p. 249.

introducing the needle alternately in front of and behind the preceding point of exit. But after completion of the operation, replacement of the trapdoor and exact suture of the wound edges with interrupted stitches, which include skin, aponeurosis, and periosteum, we remove the hemostatic suture entirely before applying the dressing. We have never seen secondary hemorrhage of any significance; however, where the soft parts are thick, as in the back of the neck, we always tie off the visible arterial lumens and always compress the operative field around the bony margin for some time very strongly after suturing the skin and removing the backstitch. The only disadvantage which this method of artificial anemia has is ecchymosis and edema of the surrounding tissue, and after trephining over the central region this may, on the second day, extend down over the eyelids to the cheek. This disturbance disappears spontaneously after a few days.

The hemostatic suture of Heidenhain accomplishes its purpose anywhere on the surface of the skull, where no thick muscle layer is present, excluding, therefore, the occipital region. In this place its influence is seldom complete, even if the hemorrhage is decreased at all. Here we ordinarily have to tie numerous spurting vessels. With this limitation, we have seen good results from this technique, even in operations on the cerebellum; but here the portion of the backstitch which runs transversely below should be placed very deep into the muscle. As for the original method of Heidenhain, to apply the stitch on both sides of every incision, there is not enough room in exposure of a hemisphere of the cerebellum, particularly in children. Ordinarily a different technique is employed in opening the skull in this region (see p. 594).

Various forms of clamps have been devised for controlling hemorrhage from the scalp during operations on the skull. Of these the flat T-clamp of Péan has long held an honorable place. Except in emergencies, these are undesirable, first because they crush and devitalize the tissues, and second because the weight of one or several on the hanging flap is likely to strip the scalp from the bone.

Recently a clamp has been devised by Makkas which has come into rather general use, and in some German clinics has displaced the Heidenhain hemostatic suture.* This consists of a powerful safety-pinlike arrangement which is introduced through the entire thickness of the scalp, and buckled (Fig. 471 *b*). There is a holder for

* Küttner, Jour. Amer. Med. Assoc., 1914, Vol. LXIII, p. 1530.

introducing it, and an instrument for removing it. These clamps are introduced to the number of five or six in such a way as to shut off the arterial supply to the operative field. We have tried repeatedly a similar type of clamp devised by a former assistant, but have found it less desirable than the Heidenhain technique.

Occasionally there will be a venous oozing from the concave side of the scalp incision which will require the application of hemostats. At the close of the operation the placing of ligatures about these bleeding points should be avoided, for two reasons: first, because ties are unnecessary in the scalp if the tissues are accurately approximated in closing up; second, because ties in the dense layers over the cranium interfere with the careful suture of the wound which is so much to be desired, and offer loopholes for infection. Cushing *

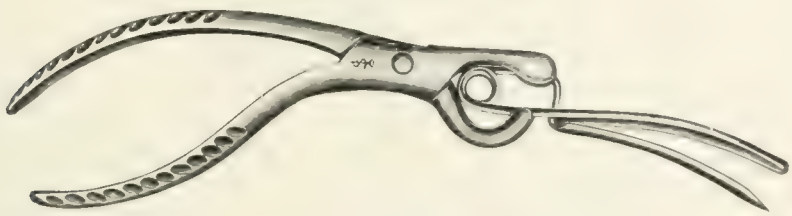


Fig. 471*b*

Makkas' hemostatic clamp.

has emphasized the importance of this matter. If a wound has to be reopened after a few days in a two-stage operation, the presence of points of staphylococcic skin infection, or even granulating edges due to inaccurate closure, greatly enhances the risk of serious infection. Accordingly the edges of the galea should be carefully approximated with a series of fine buried sutures. The skin stitches can be removed in forty-eight hours, relying upon these buried sutures to maintain accurately the approximation of the edges. The result is an incision which is hardly visible on the fourth or fifth day, completely epithelialized, and without points of reaction due to suture constriction—potential sources of infection.

FORMATION OF THE BONY FLAP

The desired flap is outlined and the incision carried immediately down to bone. The periosteum need be scraped aside with a raspa-

* Annals of Surgery, July, 1911.

tory only at the two upper corners where the drill holes are to be made (Fig. 472). Otherwise, it is only cut with a strong knife. For making the drill holes, which are carried as far as the dura mater, we employ the instruments of Doyen. With the trephine

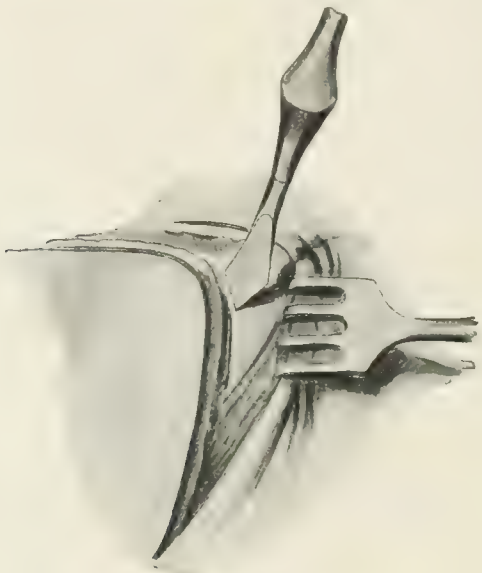


FIG. 472
The Doyen perforator is held perpendicularly to the skull.

brace carrying the drill attachment pictured in Fig. 472, 11 mm. wide at the widest point, a hole is made through the entire thickness of the skull as far as the dura, so that this is visible over the extent of one square millimeter. It is then enlarged with a

FIG. 473
Doyen burr drills, natural size.

good-sized burr drill (Fig. 473) of a diameter of 10 to 13 mm. As this does not cut on its tip, the dura cannot be injured. As a rule, only two drill holes are required. Drills have been constructed by Delbet and De Martel, which stop automatically as soon as the drill has gone through the bone.

For cutting out the bone flap, an electric motor is just as unnecessary as for making the drill holes. According to our experience, the Dahlgren rongeurs are entirely satisfactory. To prevent

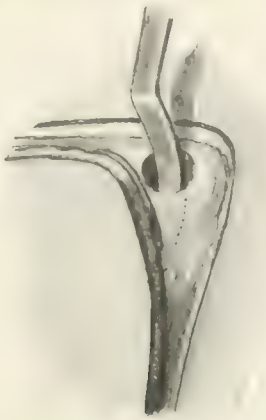


FIG. 474
Braatz stiff guide.

the dura from being injured by their use, it must first be freed up from the inner table along the line of incision through the drill-holes. For this purpose a Braatz guide is used (Figs. 474 and 475), which is made in three different curves. With its assistance

FIG. 475
Braatz flexible guide.

it is possible to separate with the dura the walls of the sinuses from the inner surface of the skull, so that in making the bone incision one need have no anxiety over the vascular spaces. Frequently in this manner we have exposed the transverse, sigmoid, and occipital

sinuses, and the confluens sinuum (torcular Herophyli), without ever having a tear in their outer walls. As regards the longitudinal sinus, great care must be taken.

In freeing up the dura from the bone, a certain slight but definite pressure should be made upon the dura and the underlying brain. This is limited to the slightest degree possible by employing a stiff guide only in the immediate neighborhood of a drill hole, and elsewhere the flexible guide. In numerous openings thus made we have never seen a harmful increase of intracranial pressure.

FIG. 476
Dahlgren cutting forceps, Krause's model.

USE OF THE DAHLGREN FORCEPS

The only disadvantage which is offered by the use of the Dahlgren forceps is the preliminary separation of the dura mater from the inner surface of the cranium, which is necessary before making the bony incision. If the bone is dense, a prolongation upward of the cutting hook, which forms the Krause modification (see Fig. 476) serves a good purpose; with the help of this lever-like attachment, one can press the hook tightly with the left thumb into the edge of bone which is being cut, and use the right hand for cutting.

If the bone is unusually hard and thick, an assistant may have to press together the handle of the forceps with his two hands, but this is only exceptionally necessary. At any rate, in the course of fifteen years' use, in a large number of osteoplastic operations, the

Exposure of the central region, with valve drainage.

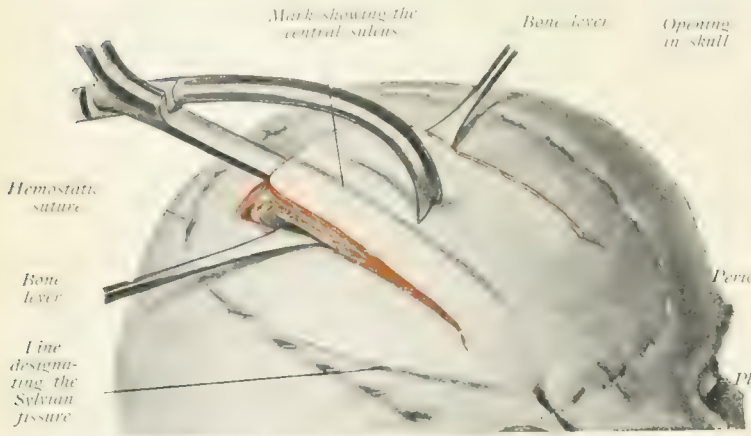


Fig. 493. The bony plate is pried up and broken back.

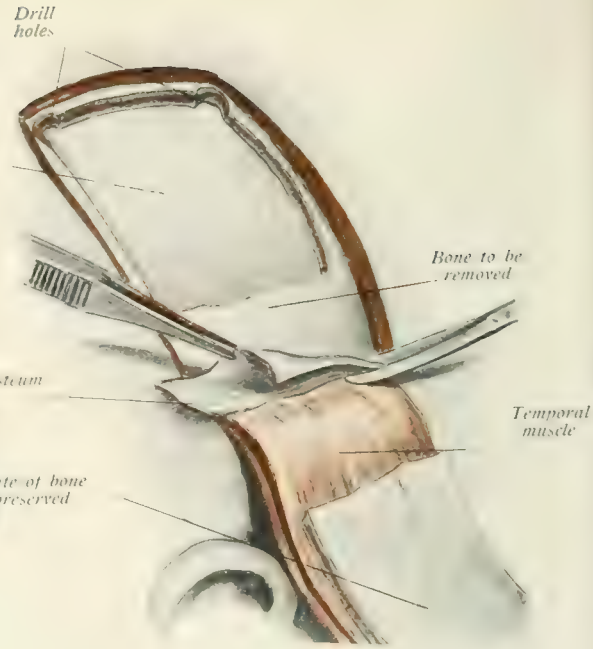


Fig. 494. The periosteum is removed over the bone which is to be broken away.

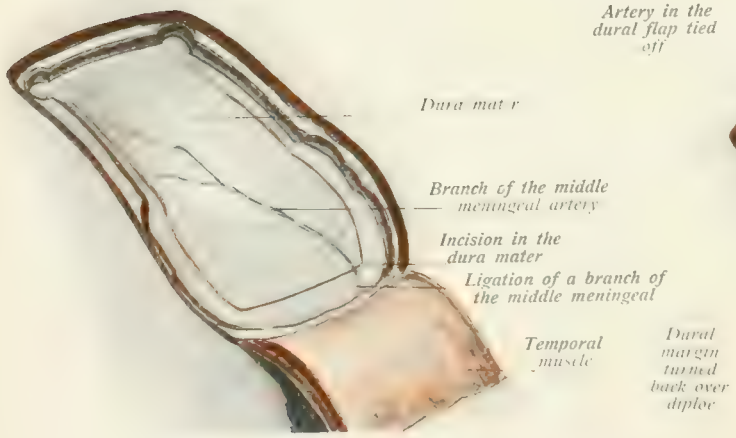

Artery in the dural flap tied off
Dura mater
Branch of the middle meningeal artery
Incision in the dura mater
Ligation of a branch of the middle meningeal
Temporal muscle
Dural margin turned back over diploe

Fig. 495. The dura mater is incised.

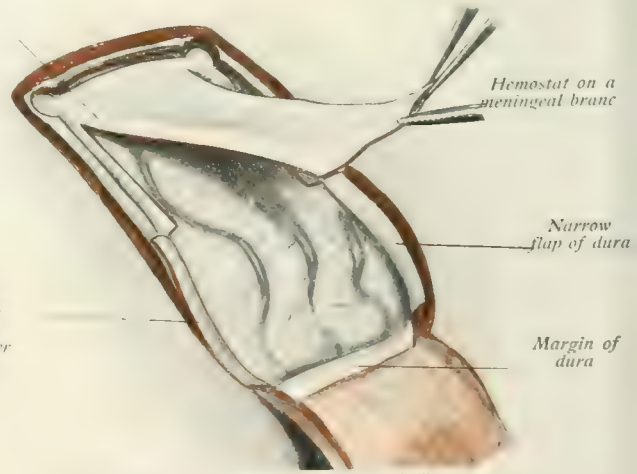


Fig. 496. Treatment of the dural flap.

Fig. 497. The dural flap is laid back into place.

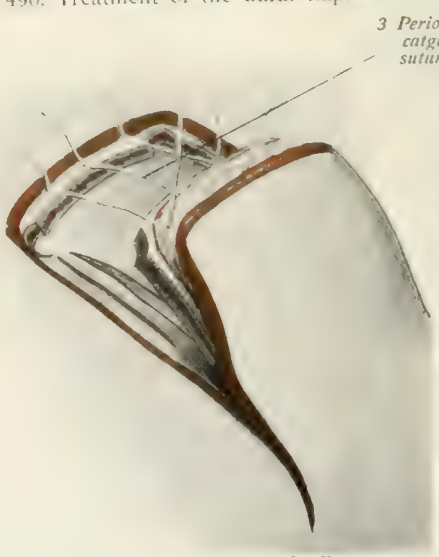


Fig. 498. Suturing the osteoplastic flap.

Dahlgren forceps has always been satisfactory, and only when the bone has been unusually thick, as for instance at the external occipital protuberance, has it been necessary first to chisel a shallow furrow in the bone so as to be able to use the forceps.

The method is simple, it is of general applicability, and it requires no electric apparatus. Naturally, as in any technique, skill will depend ultimately upon practice. Moreover, it is of no mean value from the point of view of strict asepsis to employ in the operative field only instruments which can be boiled and which take up but little room.

In this connection it seems wise to say a word of caution with reference to the electrical driving cable, even when it can be covered by a sterilizable protector. For the same reason we have our raspatories and other instruments made so short that the handles are covered by the closed hand, so as to avoid all the chance contacts to which a long handle is exposed.

Cutting out the bony flap with the Dahlgren forceps can be expedited by making drill holes at intervals along the projected line of incision. The forceps has to be drawn out after each bite, to discharge the morsel of bone cut away, and if the incision lines are long a considerable amount of time is consumed in drawing the forceps back to the drill hole, and in reinserting it. In addition to the two drill holes at the upper corners of the flap, two can be made at the base of the flap, and one half way down each side—a total of six for a flap of ordinary size. This divides the distance to be traversed between drill holes, and the forceps may be used in either direction from the lateral openings. A further saving of time is allowed if these drill holes are made with a motor burr.

Another advantage of the Dahlgren forceps, which should be appreciated, consists in the fact that one is practically independent of alterations in the thickness of the skull, which often shows great variations even in small areas. Moreover the instrument will cut in a straight line or in any sort of curve.

MAKING THE TRAPDOOR

After the bony flap has been cut, it is pried up by a wide lever which is carefully introduced between the inner table and the dura mater, and seized as far down as possible by strong bone forceps, of which one blade is straight (Fig. 493, Plate 82), and is broken back at its base. Once in a great while, when the skull is strong

and the base of the flap wide, the bone must be nicked at the base through the two drill holes made there (Fig. 477). Before doing this, however, to insure safety the dura should be separated from the inner table for a short distance on either side along the base line with the Braatz guide. The Doyen chisel is used for the pur-

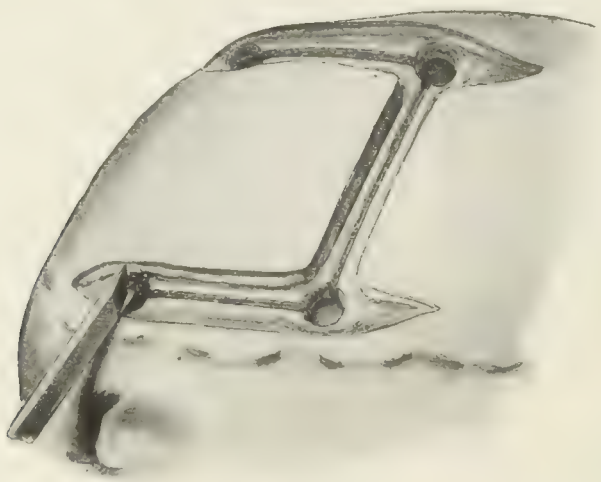


FIG. 477
Nicking the base of the bone flap with the Doyen chisel.

pose (Fig. 478). This has a blunt prolongation on one side which acts to separate the dura from the bone.

In this step of the operation the Gigli saw may also be used, provided there be no severe hemorrhage from the meningeal arteries or from the veins of the dura, which demands that the bone be turned

FIG. 478
Doyen chisel (from Krause, Brain Surgery, Rebman).

back rapidly. In prying up a large trapdoor (6 or 8 cm. wide), it may not break through below immediately on account of the elasticity of the bone; there is room enough between dura and bone to pass a Gigli saw down as far as the base, and to saw this through from within outward, while the blunt dissector protects the dura mater from injury. This technique, however, is rarely necessary, and generally speaking the routine use of the Gigli saw in outlining the bone flap is not to be advised.

To divide the cranium with the saw from within outward, two drill holes are first made in the regular way, and a Braatz guide or similar instrument is passed through between the bone and the dura; this should be left in place in order to protect the dura from injury while the bone is being sawn through. This protection is always necessary, but at the same time it has certain objectionable features; for the brain is under pressure for a considerable time by the stiff curved guide, or the clock-spring guide, which some prefer, and this must be regarded as involving a certain amount of danger. It should be a fundamental principle in these cases to subject the

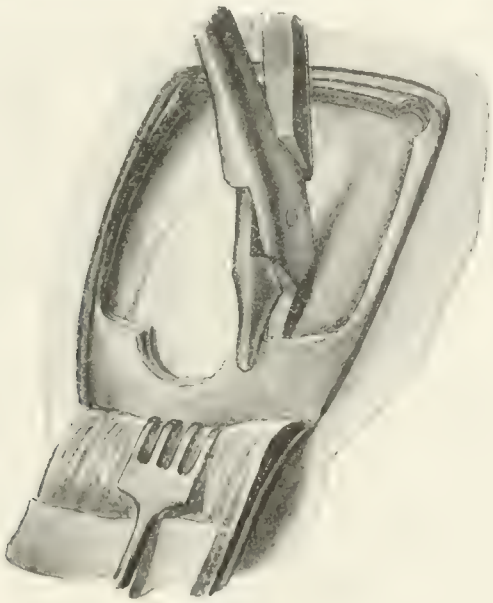


FIG. 479

Breaking away the bone with rongeurs.

dura and the underlying brain to as little pressure as possible. For that reason, in using the rongeurs (Krause's model is shown in Fig. 479), which is frequently employed to enlarge the bony opening, the connected portions of bone should always be broken away outward, away from the cranial contents.

Some surgeons make it a practice to use the Gigli saw in cutting the mesial edge of the bony flap, with the purpose of giving it a bevel. If in cutting with the saw the line of pull is not directly upward, at right angles to the plane of the bone surface, but is upward and toward the middle line, the bone will be cut on a slant, the sawn edge of the flap projecting over the sawn edge of

the rigid vault (Fig. 480). When the osteoplastic opening is closed, the flap is supported on this beveled surface, and is prevented from being driven in by the dressing, or from sinking in later, provided that it has not been necessary to remove any considerable amount of bone around the opening with the rongeurs. The same object can be obtained by cutting this portion of the flap obliquely with the Dahlgren forceps (see p. 500), but not so neatly or effectively.

When the bone flap is turned down, the periosteum must be at once shoved away at least 1 cm. from the bone below the basal

FIG. 480

Osteoplastic flap, showing the broad bevel of upper edge of bone flap, made with Gigli saw. Note the concentric rather than superimposed openings through scalp, cranium and dura. Note the tourniquet, held in place by a tape (Cushing). (From Keen's Surgery).

line of the opening in order to allow the flap to be freely displaced. For this purpose it is necessary to lengthen the lateral skin incisions downward, and this is best done, for the sake of the nourishment of the flap through the pedicle, by diverging the lines; if necessary, these diverging incisions may be carried through the hemostatic suture. By thus freeing up the periosteum, the possibility that the bony plate, in being displaced downward, becomes torn away from its periosteum, is effectually prevented. In order to avoid this possibility during further manipulations also, the soft parts of the

bone of the trapdoor are seized in the middle and held together by a special claw forcep (Fig. 481), and a similar one somewhat shorter is placed on either side at the base (Fig. 482).

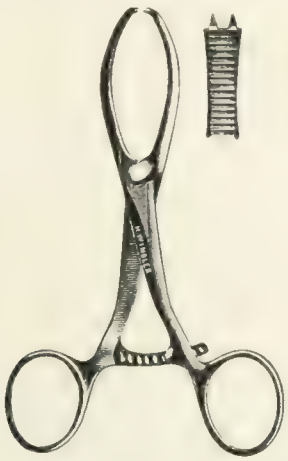


FIG. 481
Krause's claw forceps.

But it is not always necessary to have the base of the skin and bone flap directed downward, as will be shown in the illustrations and in the case histories. The base may for various reasons be

FIG. 482
Application of the claw forceps.

placed in other directions, even toward the sagittal suture, without causing disturbances in nutrition. If the base is too narrow, however, there may be necrosis of the distal corners of the bone flap.

ELECTRICAL INSTRUMENTS

In many institutions bone instruments driven by an electric motor are frequently employed in cutting out the bone flap. Doyen uses a circular saw, which has a projecting guard for protecting the dura from injury. He has extended this technique to include his operation of hemi-craniectomy, by which an entire cerebral hemisphere is exposed; the pedicle of the flap is in the temporal region. This operation is a very serious one, and is very seldom, if indeed it is ever, indicated.

Von Bergmann uses for bone cutting his electrically driven circular saw. We employed such an instrument frequently in earlier years, using, however, a saw with an axle extended on both sides, which allowed the use of both hands so that the instrument could be held steadily in spite of the vibration from the motor. The saw must be of considerable thickness so as to enable the operator to scrutinize the saw cut in the bone down to its bottom. Hemorrhage from bone and diploë is likely to be more severe when the circular saw is used than with the Dahlgren forceps. This is, no doubt, due to the fact that the forceps press together the external and internal plates, and prevent hemorrhage. A still greater objection to the use of the circular saw is the fact that the dura cannot safely be protected from injury. In this regard the Sudeck spiral burr is much to be preferred. This is actuated likewise by an electric motor, and cuts the bone in excellent fashion without danger of injury to the dura.

To obviate the objections to the circular saw Borchardt has devised a cylindrical or "plough" burr so constructed as to cut furrows in the bone of the desired depth according to the thickness of the skull, which has been determined by the preliminary drill opening. The external plate and diploë alone are cut through. The inner table is left intact. The instrument cuts a furrow from one drill hole to the other after the manner of a plow. The hemorrhage is slight, and as the operator pushes the instrument away from him, he is not spattered with blood, as is the case when the circular saw is employed. The inner table is finally cut with a chisel or with a Sudeck spiral burr.

HEMORRHAGE FROM THE EMISSARY VEINS AND DIPLOË

Even in separating the periosteum from the bone, it is possible, if the venous connections between the intracranial veins and the

scalp are unusually large, for severe and even threatening venous bleeding to occur from the emissary veins. This is infrequent, but it is most commonly observed in exposure of the posterior cranial fossa, in the region of the mastoid process, and in the neighborhood of the lateral sinus. It is very seldom met on the convex surface of the cranium, though here it is more likely to occur in the region of the longitudinal sinus. From these openings, which in the presence of certain types of superficial tumors which are supplied through the diploetic spaces, run up to the size of a goose quill,

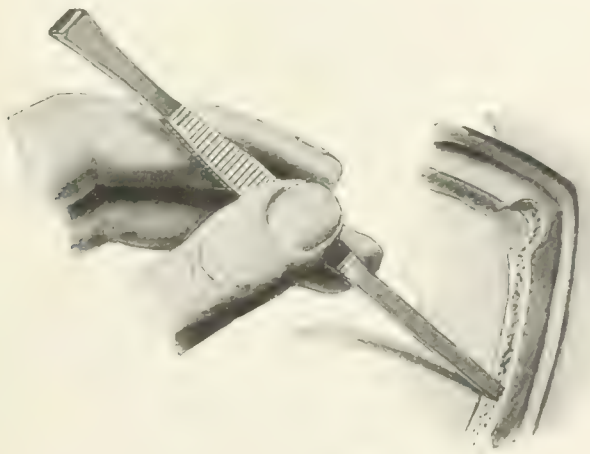


FIG. 483
Hammering down the bleeding diploë with a Passow chisel.

venous blood flows uninterruptedly, or it spurts in short jets, but without pulsation.

The venous bleeding from the cut edges of the diploë is rarely dangerous and is readily controlled by compression with gauze. Occasionally the valveless veins of the diploë bleed severely.

For mastering the hemorrhage, we have several means at hand. If it is from the diploë, a few blows with a Passow dull chisel, of which there are three sizes, usually suffices to arrest it. This technique has the further advantage that the operator can continue to work in the same place, and to repeat the process if bleeding is freshly provoked. Particularly in working on spongy bone, the method has given very satisfactory results in many instances. But if a vein occurs in the diploë as large as a fine pencil lead, even the largest Passow chisel does not suffice. Then a piece of muscle may be cut away from the exposed temporal or posterior cervical

muscle, forced into the hole with smooth forceps, and held under considerable pressure with gauze for some time until the bleeding has ceased. Instead of a bit of muscle, one may use a strip of

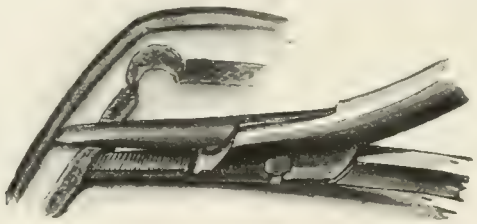


FIG. 484
Crushing bleeding diploë with flat-jawed forceps.

the cranial aponeurosis, or a sliver of bone which has been cut out with the Dahlgren forceps. The crushing of the external and internal plates together with a flat jawed forceps also controls hemorrhage from the diploë (Fig. 484). However, this technique is to be employed only in bleeding from surfaces; for open lumina the Passow chisel is to be preferred.

In other parts of the bone we press the point of a sharp elevator into the bleeding opening and twist it back and forth several times, or introduce one of the bone hooks, originally designed by Krause

FIG. 485
Krause's bone hooks for control of hemorrhage (full length is one-third natural size, tips are natural size).

for the arrest of bleeding from the middle meningeal artery (of which there are three sizes, Fig. 485). If the bone is thick enough, and the bleeding lumen is not too large, the hemorrhage ceases. Under the same conditions the hammering in of ivory pegs, of which several sizes should be available, is found helpful. When firmly seated, the peg is cut off close to the surface and left in place.

However, all these measures may fail if the cranial wall happens to be very weak or thinned out as the result of increased pressure

for a considerable length of time. In such cases the bleeding area should be plugged with a bit of the selvedge of a gauze sponge. If this is not possible, the opening is enlarged with a Doyen drill or burr, the gauze is packed between dura and bone, and around and into the opening; then finger pressure is maintained for a short while to arrest the bleeding. If possible, such places should be avoided later on in the operation, if the bony opening has to be extended.

The method originated by Horsley, of pressing aseptic prepared wax into the bleeding openings, should safely control all bleeding from the veins and sinuses in the bone, if the periosteum about them has been removed beforehand. This technique has received rather wide acceptance, but we do not employ it.

After one has experienced the difficulties arising from bleeding, from the emissaries in particular, he tries as best he can to avoid them entirely. In fact, we have several times succeeded in dissecting out the emissaries at the mastoid process, and by carefully lifting away the periosteum, have double tied and divided them. Then, after removal of the corresponding bone, we have been able to follow an emissary vein to the point where it comes away from the particular sinus and double tie and divide it at this point, as is described for the pericranial sinus (Fig. 661, Plate 111). One can also forestall hemorrhage from the emissaries by making incisions when feasible not too close to a sinus. When the bony plate is cut out, one can always increase the size of the opening by the removal of strips of bone from the edge of the opening or can fashion a second small trap-door near the first one. In either case it is easier to deal with hemorrhage in case the dura has been already exposed.

The compression or temporary ligation of one or both carotids which has been recommended by various authors, particularly Frazier; we have never found necessary.

Even in the most unfavorable cases, in our experience hemorrhage has always been controlled by one of the methods described.

BLEEDING FROM THE DURA

Venous hemorrhage which occurs in separating the dura from the internal plate between drill holes is ordinarily not significant; it ceases as soon as the Braatz guide is withdrawn, and the dura once more comes to lie against the inner surface of the cranium,

under a certain amount of pressure. However, there may be profuse venous hemorrhage in cases of brain tumor, with the first bone incision. When this occurs nothing remains to be done other than to pack gauze into the drill hole and the bony furrow with a small instrument (Fig. 486), so as to create sufficient pressure to decrease temporarily the dangerous hemorrhage. The bony incision is then rapidly completed, concluding with the portion in which the hemorrhage occurred.

As soon as the bony flap is turned down, the dural hemorrhage may be controlled by packing with gauze or absorbent cotton, or by encircling the bleeding vessel with a needle carrying a ligature.

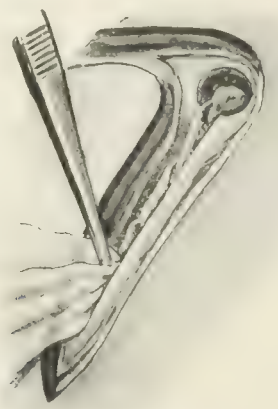


FIG. 486
Packing the oozing incision line with gauze.

In one of our cases the dural veins which lay over the tumor were as large as a pencil, and the hemorrhage therefrom was imminently serious. It was, however, controlled in the manner described, and the patient made a good recovery.

One must always be prepared for such contingencies, and there is no possible way of anticipating their occurrence. We have made it a rule in all osteoplastics on the cranial cavity to first, after completing the incision in the soft parts and controlling hemorrhage therefrom, make the drill holes required. Any bleeding from these can always be controlled by packing with a pledget of gauze. Then we loosen the dura between the two drill holes on a line corresponding to the top of the bony plate with the Braatz guide, and cut the bone across at this point immediately. Bony incisions in the neighborhood of a large sinus, particularly the longitudinal

sinus and the mastoid sinus, are usually made last, for here one is most likely to meet with strong hemorrhage from the emissaries. The torn Pacchionian granulations may also bleed very severely.

In a forty-three-year-old man in whom the lower two-thirds of the left central region were to be exposed, an unusually severe hemorrhage occurred from the diploë as soon as the drill holes were made, and it kept repeating itself as the Dahlgren forceps were used. As packing of the drill holes with gauze caused a practically complete interruption of the hemorrhage, a number of drill holes were made around the line of the bone flap which had been originally planned; they were packed with gauze, and the bridges of bone between them were cut with the Doyen chisel. In this manner we were able to successfully cut out a large bone flap and to break it down in the ordinary manner. After the dura was exposed the hemorrhage stopped on compression. In various places it was controlled by the methods described above.

If venous hemorrhage which threatens life cannot be controlled, the bone must be sacrificed. A few seconds suffice to separate the skin and muscle flap, which has already been cut out, from the bone flap, using a bone scraper. The bone is then broken away with rongeurs through the drill holes which have already been made. As soon as the bleeding portion of the dura is exposed, the experienced surgeon can make short work of even the most stormy hemorrhage.

We have been compelled to sacrifice the bone on account of venous hemorrhage only once. This was in the case of traumatic epilepsy in a man of thirty. On account of a painful depression on the vault of the cranium, at the point of junction of the two central sulci as outlined by the method of Krönlein, the bony flap had to be extended over the longitudinal sinus. Unusually severe hemorrhage occurred from the upper anterior drill hole. Packing for a considerable time was not successful in stopping or decreasing the hemorrhage. On removal of the gauze, venous blood gushed out again in a thick stream. Accordingly, the bone had to be sacrificed. Two openings were found in the longitudinal sinus from which emissary veins had been torn. The bleeding stopped on pressure with gauze, the skin and periosteal flap were sewed back over the packing, which was removed four days later, and the operation was completed after six days' interval. The patient made an uneventful recovery.

It is different with arterial hemorrhage. This is largely limited to the distribution of the middle meningeal arteries. Torn terminal branches may be seized and tied in the regular way (Fig. 487). We have repeatedly found the trunk of the artery, particularly in exposing the middle fossa for the extirpation of the Gasserian ganglion, running in a bony canal instead of in a furrow. Ordinarily speaking, hemorrhage even in this case, when injury of the artery cannot be avoided, has not been serious. In a few instances, however, in the presence of arterial sclerosis, we have found it so threatening that the bone has had to be sacrificed as

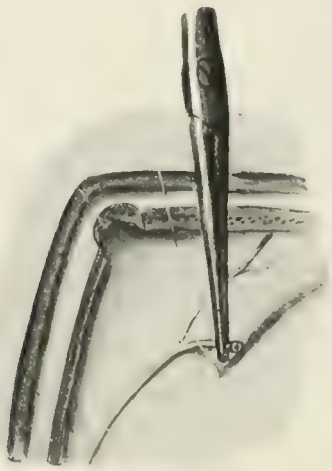


FIG. 487
Seizure and ligation of a free-lying branch of the middle meningeal artery.

already described in order to pass a threaded catgut about the spurting artery above and below.

VESSEL CLIPS

The silver vessel clips designed by Cushing,* although we are not familiar with their use, deserve more than passing mention. They are similar to the skin clips of Michel, and are made as follows: Fine silver wire is wound around a flat metal pencil, which is longitudinally grooved. By lightly tapping the wire, after winding, the inner surface of the loops become transversely ridged. A deep median groove allows the pointed wire cutters to snip the loop into clips of a uniform size (Fig. 488, 1). They are then

* Harvey Cushing, The Control of Bleeding in Operations for Brain Tumors, Annals of Surgery, July, 1911.

loaded on a magazine, and picked up individually, as needed, by the holder (Fig. 488, 2). The first "catch" of the holder locks it at a point which closes the jaws sufficiently to enable them to take

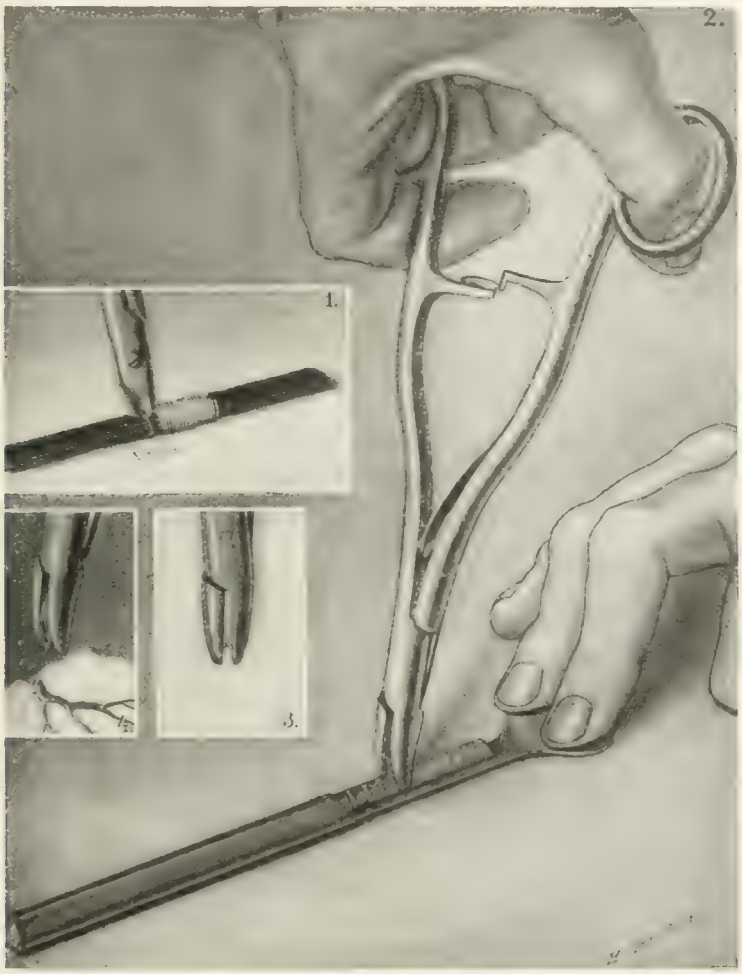


FIG. 488

Cushing's hemostatic clips.

1. Silver wire loops being cut after wrapping on grooved steel pencil.
2. One of the clips being picked up from the loaded magazine.
3. Clip in position in jaws of holder.
4. Clip placed on meningeal vessel at edge of dural incision (empty instrument shows mold for holding clip).

(From Annals of Surgery, July, 1911.)

up the loop from the magazine without deforming the easily compressed wire, and the instrument unlocks itself when the clip has been flattened against the bleeding point (Fig. 488, 4).

For the control of bleeding points in the cut dura which are inaccessible to ligation, particularly in the sub-temporal decompression operation, where the dural incision runs under the temporal muscle, which is split and retracted, he has found that these clips can be used with advantage. In the enucleation of deep-seated tumors delicate vessels may be encountered passing from brain to tumor, and lying in tissue in which the ordinary hemostat is obviously useless, and ligation well-nigh impossible. Cushing finds it a comparatively simple matter to pick up the visible vessel or bleeding point in the jaws of the holder, as with a hemostat, and clamp it, leaving the clip in place. The clips remain in the tissues without arousing any reaction.

TWO-STAGE OSTEOPLASTIC OPENING OF THE SKULL

The first stage of the operation ends with cutting out the bone and tissue flap before the dura is opened. If one intends to carry out the brain operation proper after an interval of time has elapsed, the soft parts of the flap are sewed back into place with buried interrupted sutures of catgut or silk. A careful and exact approximation as already stated (p. 469) is the best technique on the ground of asepsis, and because the skin does not undergo shrinkage. If for any reason one desires to permanently avoid healing in of the bone flap, a strip of periosteum and bone at least one cm. wide must be removed around the flap with Dahlgren forceps or rongeurs.

Operations on the brain are usually extensive and serious, so that it is always a conservative procedure to carry them through in two stages provided there is no contraindication. Brain abscesses are ordinarily completed at one sitting; but with most brain tumors, a delay of eight or ten days in extirpation involves no disadvantage; in epilepsy, where one has to do with a disease which has lasted for years, operation may be carried out in more than one stage without the least hesitation. General rules, however, cannot be laid down. Sometimes the development of serious hemorrhage or collapse compels us to interrupt the operation after the trap-door has been made; in most cases, however, the surgeon has his choice, and it is then a case of judgment as to whether the operation should be completed or not. We have frequently seen the cardiac activity and the pulse remain good for a long time in brain operations and then suddenly deteriorate without loss of

blood; a fatal result can often only be avoided if, as soon as such collapse appears, the operation is immediately interrupted.

The two-stage operation has certain disadvantages. Nevertheless, we have, generally speaking, favored the two-stage operation, following the precedent set by Victor Horsley, although we have carried out extirpation of tumors and even exposure of both hemispheres of the cerebellum, which is a considerable operation, at one stage, with entirely satisfactory results.

It is not the act of trephining alone which in the first stage has such a serious influence on the organism. In other parts of the body we perform extensive and bloody operations without the occurrence of similar collapse. But with a wide opening of the cranial cavity the intracranial pressure is markedly disturbed, and such a change cannot take place without a deleterious effect upon the cardiac activity, blood pressure and respiration. In this way may be explained the manifestations of shock, which we see unfortunately all too frequently in brain operations. The substitution of local for general anesthesia offers no particular advantage in this regard.

Horsley believes that by allowing warm salt solution or weak corrosive sublimate (one to ten thousand) at a temperature of 115° F. to trickle continually over the exposed brain, not only is hemorrhage prevented, but collapse is avoided. We advocate dry asepsis too firmly, however, to be able to accept this technique. Moreover, we have seen in Horsley's hands that with this trickling of fluid a safe estimate of the amount of hemorrhage from the injured veins of the brain was impossible.

If it has been found necessary to leave gauze packing in the wound on account of venous hemorrhage, it is removed on the average after five days, and at the same time all stitches are taken out, so as to procure for the second stage of the operation a completely healed, and accordingly a strictly aseptic field. For the same reason, all stitches are removed by the third day in sutured wounds that have healed by first intention. In the posterior fossa alone a few sutures must be left at the upper margin of the wound until the second stage, to prevent contraction of the powerful muscles of the back of the neck from tearing open the wound and causing it to gap.

The question as to how long a time should elapse between the two stages cannot be answered generally; it depends upon how

quickly the patient has reacted from the osteoplastic operation, and also upon the nature of the disease for which the operation is being performed. An interval of six to eight days is to be recommended, but in case of necessity one can wait nine days to two weeks. But after two weeks or even three one can reopen the young scar with blunt instruments. One finds the wound cavity filled with clot, which is likely to be so adherent to the dura that it cannot be wiped away, but has to be removed with a curette.

OPENING THE DURA MATER

A crucial incision of the dura has no advantage, and it narrows to a marked degree the area over which the brain is exposed. It

FIG. 489

Passing a ligature on a needle around a branch of the middle meningeal artery.

is preferable to cut out a quadrilateral flap. If the tension is but little increased over the normal, it is impossible to pick up the dura over the underlying brain with mouse-tooth forceps; then it becomes necessary to incise the dura carefully *in situ* for about 1 cm. with a pointed knife. The edges are seized with forceps so that the arachnoid space is exposed, and starting from this opening, the incision is completed with small blunt-pointed scissors, or if the brain pressure allows it, by passing a small spatula under the dura and cutting upon this with a knife.

The base of the dural flap does not necessarily have to be directed downward, and need not correspond to the base of the bone and tissue flap. If one has to work in the direction of the longitudinal sinus, it is of advantage to direct the base toward the median line.

It is then feasible by careful tension on the flap, which is turned toward the median line, to expose the cortex almost to the median fissure, and injury of the great sinus, and what is just as important, of the numerous thin-walled and sometimes rather large veins which run from it to the pia mater, is avoided far better than if, with the base laid in another direction, the dura were cut parallel to the longitudinal sinus.

Fashioning the base of the dural flap in just the opposite direction to the bone and tissue flap is also recommended at times on other grounds. If the wound cannot immediately be closed by suture after completion of the operation, if it has for any reason

FIG. 490
Ligature completed.

to be kept open for several days for drainage as, for instance, in brain abscess, hernia of the brain from injury of the pia mater and increase in intracranial tension will result, which may reach considerable dimensions. If the wound, after a little time, is clean enough to allow of secondary suture, the skin and bone flap will be found insufficient to cover the hole. The dural flap which extends from the opposite direction, although it has shrunken considerably, can well be utilized under these circumstances.

In operating within the region of distribution of the middle meningeal artery, it is advisable to pass a ligature on a needle around the larger branches before cutting the dura (Figs. 489 and 490), in order to avoid trouble from hemorrhage.

INJURY AND RESECTION OF A SINUS

At times conditions demand that the incision in the dura approaches so closely to one or another of the large sinuses that we have to be prepared beforehand for their injury. In connection with the longitudinal sinus, particular care should be taken with regard to the lacunæ which empty into it; their walls are much thinner than those of the sinus itself, and they may extend on either side of it for as much as a centimeter. In order not to get too close to the longitudinal sinus and the veins which come off it, it is recommended in cutting the dural flap to make the upper incision at a considerable distance from it and, if necessity demands, to make a separate little flap of dura with its base above by means of two short perpendicular incisions running toward the sinus, the length and course of which may be controlled carefully by first lifting the dura.

A few remarks on the two most important sinuses may well come in here.

The longitudinal sinus runs ordinarily somewhat to the right side of the middle line, practically always so in its posterior section; for that reason the origin of the two lateral sinuses varies. The width of the longitudinal sinus, in the upper part of the sagittal suture, inclusive of its walls, is from 6 to 8 mm.; in the middle between the lambda, which is the junction of the sagittal and lambdoid sutures, and the inion, that is to say, the external occipital protuberance, it becomes wider, and just before reaching the latter point it is 12 to 15 mm. wide.

The lateral sinus corresponds in its course by and large to the superior nuchal line of the occipital bone, until it reaches the asterion, where the parieto-mastoid suture meets the lambdoid, at which point it makes a sharp turn. It continues in the sigmoid groove, which runs in a line corresponding to the middle third of the base of the mastoid process.

If there has been injury of the wall of a sinus, the bleeding hole is clamped delicately with one or more mosquito forceps, and is sewed behind them with a very fine cambric needle and silk. The technique of acupressure may also be used in larger dural veins, particularly those in the region of the Pacchionian granulations, and in the large veins of the pia mater which open into the sinus.

RESECTION OF A SINUS

Resection of a sinus is sometimes demanded in extensive disease, particularly in the case of tumors. If one of the large sinuses which lie on the inner surface of the skull (the lateral, longitudinal or occipital sinus) is divided, enough of the bone must be removed so that the contour of the sinus may be readily examined, and so that it may be freely approachable from both sides. But it is not always necessary to sacrifice the bone; ordinarily it will be found feasible after the formation of an osteoplastic flap to lift the sinus, together with the dura, away from the internal plate uninjured. We have repeatedly freed the lateral sinus from its deep bony furrow, the sigmoid groove, in order to gain access extra-durally to the posterior surface of the petrous portion of the temporal bone.

If the affected sinus is exposed, the neighboring dura is incised parallel or at right angles to its course, that is to say, on both sides, close to it. By introducing a probe, it may be determined how far the incision should extend. Then corresponding to the two dural incisions, an ordinary blunt needle or a Deschamps aneurism needle loaded with catgut (linen and silk cut through too readily) is passed about the sinus. This in the case of the longitudinal sinus must penetrate the falx, in the lateral sinus the tentorium, and with the occipital sinus, it must surround the falx cerebelli. Then in a similar manner several millimeters away a second ligature is passed around the sinus, which is then cut between the two firmly-tied ligatures.

A strip of the tentorium cerebelli may be removed after the lateral sinus has been tied off, but the straight sinus should never be injured. A similar procedure may be employed with the falx cerebri. But with the longitudinal sinus, this offers great difficulties, because the numerous veins which run from the convexity of the brain to the pia mater must be tied off. In this manner we have frequently in living subjects excised portions of the dural processes described.

The smaller sinuses, for example, the spheno-parietal sinus of Breschet which follows the course of the anterior branches of the middle meningeal artery, and runs parallel to the coronal suture down to the cavernous sinus and falls in the operative field when

the skull is opened in the region of the temple, are not difficult to double tie and divide.

For opening the posterior fossa, special instruction will be given in a subsequent chapter.

CRANIOCEREBRAL TOPOGRAPHY

When the focus of disease in the brain has been diagnosed and its location determined, the opening should be so planned as to lead as directly as possible down to the desired section. For that reason it is important for the surgeon to be acquainted with the relations between the convolutions of the brain and the surface of the skull. While we owe recognition for the earliest and most extensive researches in this determination to the anatomists of France, skillful surgeons as well, we are also indebted to Adolph Pansch for his great service in having established the particular significance of the fissures as compared with the convolutions.

KRÖNLEIN'S FORMULA

We can orient ourselves readily on the cranium if we know the positions of the fissures of Rolando and Sylvius. The simplest technique for localization of these fissures is the formula of Krönlein, which is described in Fig. 112.

The following construction lines are drawn on the skull:

1. The base line (the so-called German horizontal), which, according to the Frankfurt agreement, is drawn through the lower margin of the orbit and the top of the external auditory meatus;

2. The upper horizontal, which is drawn parallel to the first through the upper margin of the orbit;

3. The anterior vertical (Z) which is drawn from the middle of the zygoma perpendicular to Nos. 1 and 2;

4. The middle vertical (A), a perpendicular drawn from the condyle of the lower jaw;

5. And the posterior vertical (M), a perpendicular drawn from the posterior edge of the base of the mastoid process.

The line of the fissure of Rolando (RP) joins the point of contact of the anterior vertical and the upper horizontal (K) with the point where the posterior vertical meets the middle line (P).

The line of the fissure of Sylvius (KS) bisects the angle (PKK). The line of bisection is lengthened backward to the posterior vertical. Fig. 491 explains this construction.

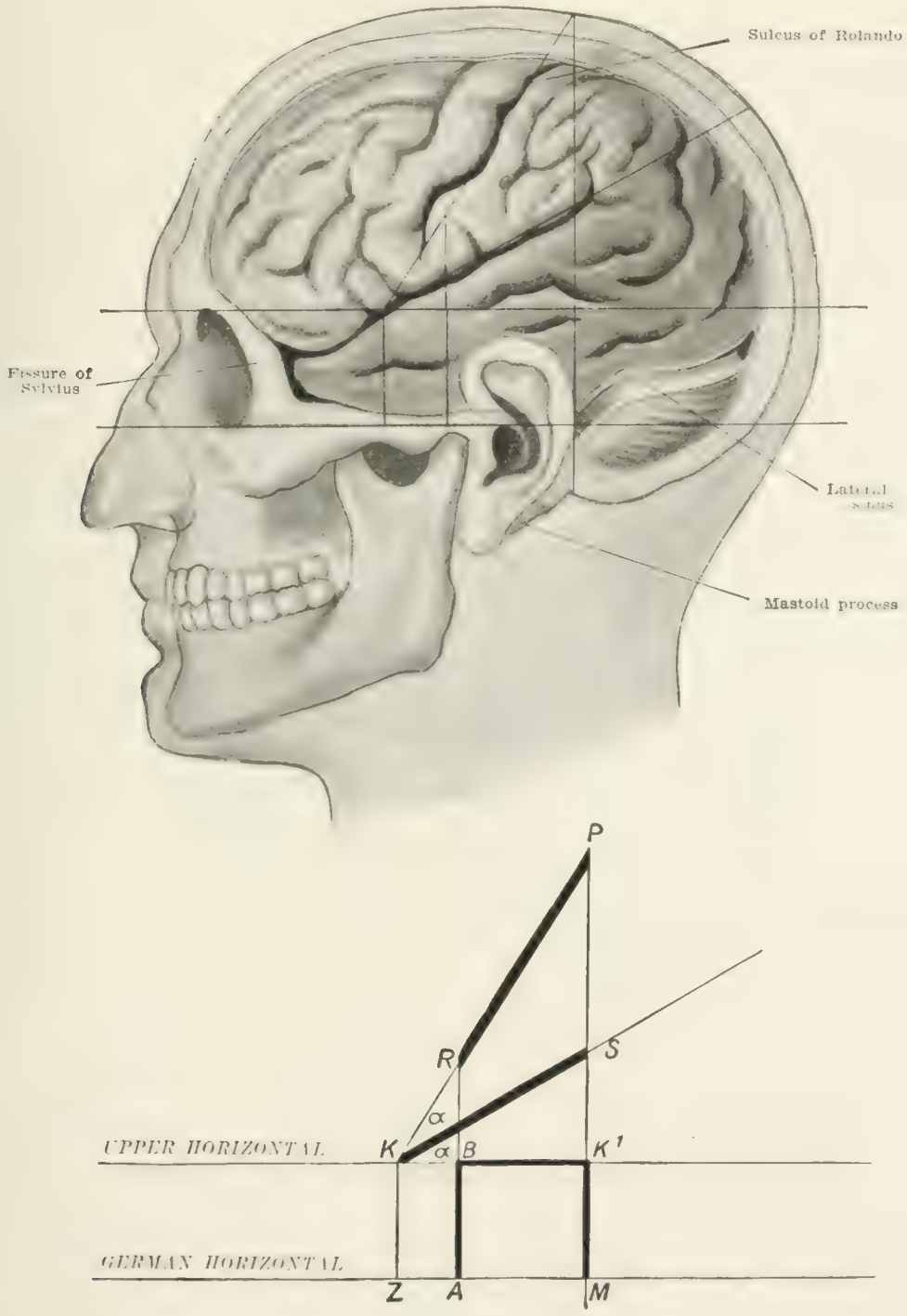


FIG. 491

Krönlein's scheme for locating the central sulcus and the fissure of Sylvius on the shaven scalp.

K = point of division, S = posterior upper end } of the fissure of Sylvius.

R = lower end, P = upper end } of the central sulcus.

It is good practice twenty-four hours preceding operation, after the head has been shaved, to lay out these two chief fissures upon the scalp with a silver nitrate pencil.

The central sulcus (of Rolando) will serve as the best guide of localization on the surface of the cerebrum, and when its location has been marked on the scalp, it is easy to draw in the

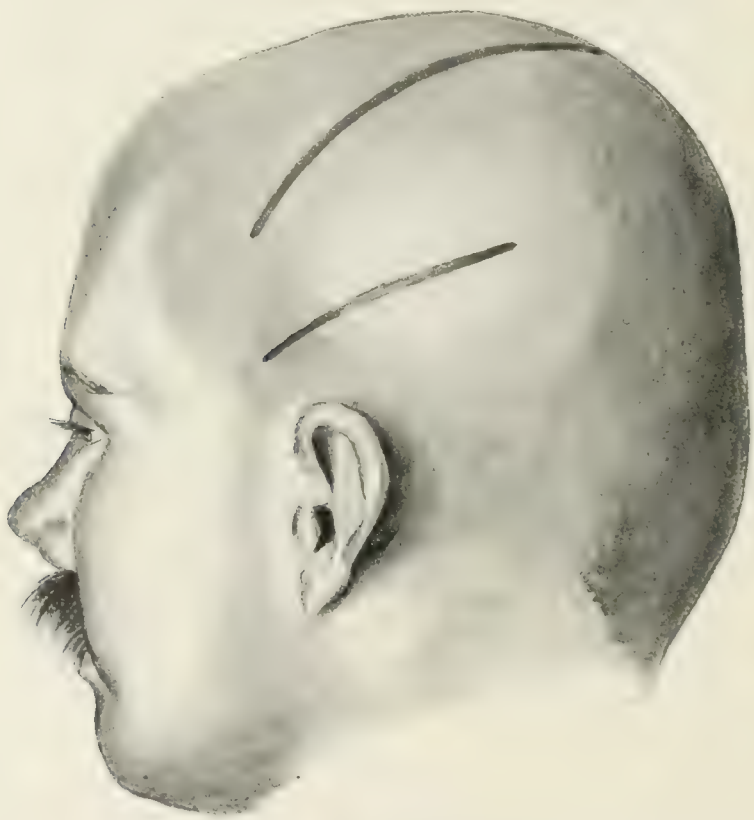


FIG. 492

The fissures of Rolando and Sylvius as marked on the cranium by the method of Krönlein, preparatory to operation.

precentral sulcus, which is parallel to it, 18 to 20 mm. in front of it. Determination of the location of the lateral cerebral fissure (of Sylvius) is likewise of importance.

In the majority of our operations, carried out on all sections of the brain, Krönlein's formula has been entirely satisfactory; nevertheless, we have several times employed the Kocher kyrtometer, as it is practicable to know several methods for determining the location of the main fissures. No formula can be con-

sidered infallible, however. For this reason we are at present compelled to make osteoplastic flaps of considerable size.

As a rule we employ a modification of the Krönlein technique, which was originated by Hare. By this shorter method the lower end of the central sulcus (of Rolando) is placed in adults 7½ cm. perpendicularly above the external auditory meatus on the shaved scalp, and the upper end of this sulcus is placed where a perpendicular line drawn from the posterior margin of the mastoid meets the sagittal line. With this simple formula, one can always determine the central sulcus with fair accuracy.

CHAPTER 19—SURGICAL TREATMENT OF EPILEPSY

According to the present-day point of view, in true general epilepsy, as in the Jacksonian type, the cortex of the brain is of great significance as regards the motor discharge initiating the attacks. Convulsions of an originally Jacksonian character can, in the further course of the disease, develop into a general epilepsy.

On the other hand there are cases of genuine epilepsy in which the convulsion, particularly in the earlier stages of the disease, is likely to begin in a definite and limited muscle group or in one side of the body, or to limit itself chiefly to this area, and in which consciousness is not lost. Further factors, among others the hereditary taint, make the diagnosis possible. It must also be observed that in epileptics, in whom at first no focal symptoms are present, paralysis may develop in the course of the disease.

These manifestations must be known to the surgeon, because they offer the possibility of localization, even in general epilepsy. Redlish has shown us the significance of skin and tendon reflex in this regard. Finally, the configuration of the skull, and particularly the roentgenogram as Schüller has demonstrated, may show deviations which point to a localized injury of the brain, and, as a rule, indeed, only in one hemisphere. On the surface of the brain itself, the anatomical findings of porencephalus, microgyria, and sclerotic processes have often been demonstrated over a wide extent; in addition we have to consider atrophic conditions in the hemispheres, internal hydrocephalus, and less frequently external hydrocephalus.

TREATMENT OF GENERAL EPILEPSY: A CASE WITH SUSPECTED JACKSONIAN CHARACTER

A fifteen-year-old boy had suffered for two years with epileptic convulsions, repeated two or three times a month, having a year previously received an injury at the back of the neck. First there appeared spasms in the left hand, left arm, and left leg. Then there was a feeling of weakness, and the convulsion became general

and the boy unconscious. Before the general attacks appeared, they were present in an abortive form for about six months; the patient, if sitting, had the feeling as if he had twisted around on a stool, or in standing that he would fall, and at the same time he experienced the convulsive spasm in the left hand. The aura consisted in a roaring in the right ear.

Examination showed a strongly built boy of healthy parents. No signs of organic disease of the nervous system could be made out. Only the left corner of the mouth seemed to be somewhat more poorly innervated than the right; the patellar reflex was active on both sides; the toe reflex on the left side was rather indefinite, it occurred sometimes dorsally, nevertheless there could be no question of a positive Babinski.

From the history and from our own observation the case was diagnosed as one of epilepsy of the Jacksonian type, the origin of which was to be sought perhaps in a meningoencephalitis which had occurred in childhood. Slight meningeal changes (thickening, scars, and arachnoidal edema) might have occurred over the motor zone, but on this point one could only conjecture. However, there was no question about this being a case of general epilepsy, although a number of symptoms pointed to the right hemisphere, and the attacks which formerly, at least, began in the left side of the body had left behind here also slight disturbances. Exploratory operation over the right central region (centers of forearm and leg) was all the more indicated as the patient for more than a year had been under treatment with a neurologist, and through others had received large doses of bromide, and also because his mental activities, particularly memory, had shown regression. The uncertainties of result were explained to the family, but they decided, nevertheless, in favor of operation. A trap-door was to be made through which the central region could be exposed for a sufficient extent to allow of a search for pathological changes.

After the method of Krönlein, the central sulcus (of Rolando) and the lateral cerebral fissure (of Sylvius) as well as the sagittal line were marked upon the shaved skull with silver nitrate.

The hemostatic suture was introduced around the entire field of operation with two running sutures, that is to say, with one interruption (Fig. 493, Plate 82). The incision went immediately down to bone, and it surrounded an area which included easily the width of the entire anterior central gyrus and half of the posterior.

The periosteum was scraped away from the bone only at the upper corners of the incision, over sufficient extent to allow two drill holes to be readily made. Then with the Braatz guide, the dura was freed up from the inner aspect of the skull corresponding to the posterior margin, and the bone was divided for two-thirds of the length of the skin incision with the Dahlgren forceps. After the same procedure was carried out at the anterior margin, the bone was finally cut across above.

The bone flap was then lifted up in front and behind with two levers (Fig. 493) and was broken back with the Krause-Langenbeck forceps (which has two long arms, the one which is to be passed under the bone being not curved, but straight). In this way we obtained a quadrilateral bone plate which covered over two-thirds of the operative field (Fig. 494, Plate 82). This plate hung only by the skin and temporal muscle, while the periosteum of the pedicle of the flap, which remained attached to the skull, was cut transversely across below on the temporal muscle and removed (Fig. 494). Thereupon the bone which remained below the opening was broken away as far down as the reflection of the muscle, and the hole at this level was still further enlarged in front and behind, by the removal of a small strip of bone (Fig. 495, Plate 82).

A valve opening was to be left in the region just described. With this purpose in view, the dural flap had naturally to be cut with the base upward. The first incision for opening the dura divided it transversely below, three-fourths of a centimeter away from the bony margin, and from the ends of this incision two vertical incisions were carried up the same distance from the bone, parallel to the lines of the skin flap (Fig. 495). The divided anterior branch of the middle meningeal artery was tied off with catgut passed about it on a needle; and this procedure had to be repeated at the posterior margin of the flap. In the flap itself a small branch of the meningeal spurted and was tied off in the same way, a sign of the good nourishment of the flap, although its base lay upward. A place in the diploë, from which the venous hemorrhage was strong, was controlled by hammering it in with the Passow chisel.

The arachnoid, as is common in epilepsy, showed edema, and accordingly it was pricked in several places. At the lower edge the dura was incised vertically in front and behind, and the narrow

margin was turned down over the cut surface of the bone (Fig. 496, Plate 82). The remaining dura was likewise incised in front and behind as far as the bone at a point corresponding to the desired level for the top of the valve, and the flaps turned over the bony edge in front and behind respectively, so that the diploë was completely covered and the brain protected from injury from the edges of the bone. However, in the upper region of the opening where the bone remained untrimmed, the narrow strip of dura was left undisturbed. Finally a puncture was undertaken in order to see whether an abnormal quantity of fluid was present either subcortically or within the lateral ventricles; this was not found. As the case was not one of typical Jacksonian epilepsy, exception was taken to Faradic stimulation of the cortex and possible excision of the primary convulsing area.

The large dural flap was now turned down in such manner that a portion of the brain, 2 cm. high, remained entirely uncovered below (Fig. 497, Plate 82). Likewise in front and behind, as the result of retraction of the dura, a strip of the brain a scant centimeter wide remained uncovered by dura. Finally, at the upper margin of the wound, the periosteum of the bone flap was carefully united to the periosteum of the skull by three catgut sutures (Fig. 498, Plate 82), in order to obtain real bony union and to anticipate any sinking of the bony plate. To give added security, the catgut sutures penetrated also the innermost layer of skin. Finally the skin flap was carefully sewn back into its former position by means of interrupted sutures of silk, and the hemostatic suture immediately removed. The slight hemorrhage could readily be controlled by four hands pressing strongly on the skull about the margin of the bony opening.

The convalescence showed nothing of note and practically no changes of any significance occurred either in the temperature or pulse; there was no flow of cerebral fluid, so that the dressings remained dry and had to be changed for the first time ten days later, at the time of the removal of the stitches. In three weeks the patient had left the bed and soon after the hospital. The bony plate had healed in place so that it was immovable. The valve under the temporal muscle remained in the manner intended.

Of the further course, we know only that no more attacks appeared in the first six months; later news we have not been able to obtain, as the patient came from a considerable distance.

TECHNIQUE OF THE FORMATION OF THE VALVE

The suture which brings the two upper cut surfaces of the bone into contact (Fig. 498) is particularly necessary, in order to prevent the temporal muscle from pulling the bony plate downward. If the periosteum is thin, as is usually the case in young persons, one can do better by placing one suture anteriorly and one posteriorly through the upper layers of the bone by means of fine drill holes, going also through skin and periosteum, close to the line of incision. By drawing upon these tightly, the bony plate is brought in contact with the edge of the bone at the upper margin of the opening, which assists in bringing about a firm union. These two sutures, for which medium aluminium bronze wire or strong silk can be used, may be left in fourteen to sixteen days.

One can prevent sinking in of the bony plate at the upper margin with considerable assurance by dividing the bone at this point obliquely rather than vertically, so that the upper margin of the bone plate after the periosteum or bone suture rests on a sloping flange of bone. This is difficult to do with the Dahlgren forceps; for this reason the Gigli saw is often used in making the transverse bony incision, cutting the upper edge of the trap-door on a slant, as shown in Fig. 480. Likewise it may be of some advantage if irregularities exist on the original bony margins, for the replaced bony plate finds support on them, and bony union advances accordingly with just so much more assurance.

If for any particular reason the central region has to be exposed widely from top to bottom, and a less extensive valve opening is desired, the bony plate must be cut away further at its lower margin, so that the valve opening may only form a third to a fourth or still smaller portion of the total opening.

In many cases in making the opening one does not know whether, on account of negative findings in the brain and arachnoid, a valve must be made or not. One must then cut out the bony plate in connection with the superimposed soft parts over the entire extent of the opening, and if as the result of examination a valve is determined upon, a strip of bone of the proper width can be removed from the bony plate below. This may be done with a Gigli saw, which divides the bone from within as far as the periosteum. Sometimes the Dahlgren forceps are used, although if one proceeds carelessly, one cannot prevent loosening up a little of the surrounding

periosteum. But if the bony plate is held very firmly, the periosteum may be preserved entirely, being careful in loosening up the small section of bone from the periosteum with the raspatory and scissors.

When the osteoplastic opening is made according to the method above described, to make the valve when the dural flap is cut with its base upward, a strip of dura about two millimeters wide must be removed from the lower margin of the flap, in order that the brain shall remain uncovered over a sufficient extent.

The periosteum should in any case be removed in children at the place where it is intended to make the valve, in order that there be no new bone formation. The valve may accordingly be formed under the temporal muscle in a manner similar to that which Cushing describes for his subtemporal decompression operation. While we consider this method unsuitable, generally speaking, for increased intracranial pressure (see below), it is thoroughly practicable in such cases of epilepsy as the one described.

OPERATIVE INDICATIONS IN TRUE GENERAL EPILEPSY

Operative procedures in general epilepsy go back to the time of Kocher. He favored the idea that sudden increases in pressure in the cerebrospinal fluid which was present in large quantity and was already under high tension, would suddenly suspend consciousness and incite a general convulsion. In order to rapidly control the variations in pressure, Kocher recommended the formation of a movable valve, and in case of necessity, to repeat the formation of small valves.

There is no question but that the intracranial pressure reaches a somewhat high degree during epileptic attacks. Stadelmann showed this by a direct measurement of the tension of the fluid; he found the pressure to rise as high as 500 mm., the normal pressure being only 35 mm. Moreover, we have observed attacks which have taken place in a few epileptics during operation, and in the attack have seen the brain protrude bladder-like from the cranial opening, under the strongest tension, and with a dark bluish-red color. However, through the researches of August Bier, evidence has been adduced that venous hyperemia of the brain and increased tension within the cranial shell does not give rise to the epileptic attack; nor do sudden variations in pressure, even in the most severe epilepties, who react to mental excitation immediately by a convulsion.

In spite of this, there can no longer be any doubt but that a true general epilepsy in individual cases is favorably influenced by the formation of a valve. Up to the present moment, however, a solid foundation and an assured point of support upon which to base our indications is lacking; we can only feel our way gropingly. It is to be hoped that we will soon possess clear cut indications for operative interference in this disease.

One thing can be said, in so far as our prognosis can ever have any pretension to assurance, that the danger of life in the one-stage valve operation is exceedingly small. The operation only exposes the surface of the brain and does not proceed into the depths of the organ. Indeed, one can carry out the operation without a general anesthetic by means of the novocain-suprarenin anesthesia of Braun, so that even in concomitant disease of the heart or lungs, there is no contra-indication on account of general anesthesia.

We make the osteoplastic flap over the precentral gyrus, in right-handed persons on the right side, although we have very seldom observed disturbances in innervation on the opposite half of the body. If the convulsive attacks point to a predominating participation of the left hemisphere, the operation is carried out on this side.

According to Kocher, in making the osteoplastic flap the bone and dura are to be sacrificed. Bony closure of the opening in the skull should in any case be prevented. But for that purpose the bony plate need not be completely removed; for many years we have employed exclusively the technique pictured on Plate 82, because it offers the advantage that one can examine the entire central region to see whether alterations such as cysts, scars, etc., demand further procedures.

The alterations which are found on the surface of the brain in true general epilepsy, if anything pathologic at all is found here, consist usually in edema of the arachnoid, and in chronic leptomeningitis which can ordinarily be recognized in the form of various wide grayish-white stripes along the vessels. Operatively no attention need be paid to them. Small white spots and, with a thicker infiltration, yellow plaques may also exceptionally appear.

In the characteristic picture of edema of the arachnoid, very little or nothing at all can be seen of the surface of the brain; the pial vessels, particularly the veins, appear as through a thick veil (Plates 84 and 86). Before proceeding further with the operation, the

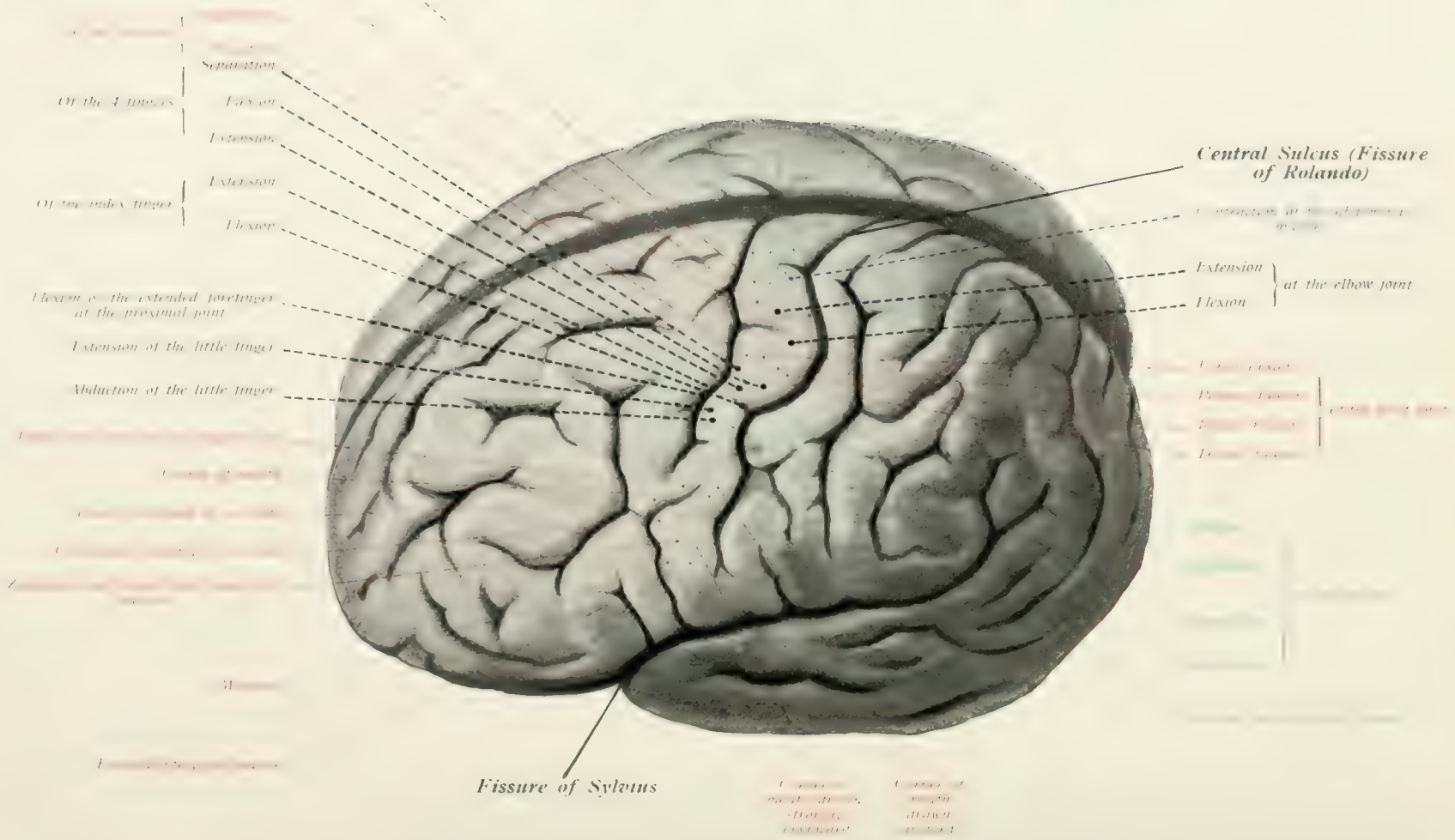


Fig. 499. Left cerebral hemisphere of man showing the centers as demonstrated by faradic stimulation by F. Krause
All foci lie in the anterior central convolution.

edema of the arachnoid must be relieved. This is accomplished by very superficial punctures and tearing with a small pointed knife, preferably in the most dependent portion of the operative field. The trickling away of the subarachnoid fluid which immediately sets in is encouraged by light compression with gauze sponges, and the convolutions and the sulci of the brain begin to show up plainly. In this process one should avoid the vessels with the greatest care; for if a vessel, particularly a vein, is pricked an ecchymosis of wide extent may arise which with its reddish-brown discoloration makes further orientation difficult. The brain surface which lies in the operative area is always covered with pia mater; the two are for the surgeon inseparable structures.

TREATMENT IN JACKSONIAN EPILEPSY

The findings here are of a manifold nature and must be taken up individually one by one, since upon them the nature of the surgical measures depend. This form of epilepsy is no disease *sui generis*. It represents rather a symptom complex which occurs in many diseases of the brain and its membranes, and may, therefore, be aroused by the most varied causes. Occasionally it forms the source of origin of a genuine epilepsy, even if the causal factor has been removed by operation (true secondary epilepsy). However, differentiation of true epilepsy from epileptoid manifestations sometimes offers insurmountable obstacles.

The typical Jacksonian attack must in any case be set off as something definite. In the first place, the convulsion affects one side of the body and usually only one section of a limb. There occur clonic contractions which in their orderly progression point to the cortex in the motor region as their place of origin (see Plate 83). In a sequence analogous to the anatomical arrangement of the centers here, the attacks spread from the region first involved to the neighboring regions, until by further extension they may go over from one side of the body to the other, and finally develop into a general convulsion. The convulsion may cease as soon as it has affected a single limb. In other cases, immediately after the first contraction of a limb, convulsions become general. Consciousness may be maintained or lost; the latter is usually the case when the convulsion spreads over the entire body, while in the beginning of an attack the consciousness is usually unclouded so that the patient may himself observe his condition.

The post-epileptic paralysis or paresis which sometimes follows the attack is very characteristic; it persists for a shorter or a longer time, involving particularly or exclusively the section of the limb in which the spasm first occurred. In this way they may aid in a determination of the center from which the motor discharge started.

Occasionally if the central region is examined with an electrode, we have been able to induce a typical attack by stimulation of a certain point on the cortex; in fact, when the determination of the focus offered difficulties, and the stimulation accordingly had to be repeated frequently, attacks occurred several times in succession in the same patient. Just preceding the beginning of the convulsion the careful observer could remark isolated movements in the limb corresponding to the particular focus, which would immediately go over into a general convulsion. Interrupting the stimulation at once before the convulsion began would sometimes prevent this from taking place, but not always. In certain cases, we have been able to stop the epileptic attack only by immediately deepening the anesthesia. Since the same result cannot be obtained by stimulating the surface about the focus with the same current, we have to do, accordingly, with an area of the cortex which has an increased irritability, and from which convulsive attacks originate on stimulation. We call this the primary spasmic center.

DETERMINATION OF THE PRIMARY SPASMIC CENTER

In the operation for Jacksonian epilepsy without findings in the cortex, the primary spasmic center must be determined in the individual case by unipolar Faradic stimulation. When the arachnoidal edema has been drained off by pricking, and the convolutions, particularly in the neighborhood of the sulci, are no longer hidden by this veil, stimulation of the cortex will give exact results. Faradization is accordingly undertaken with the pia intact, and the arachnoid is always punctured in places which are some distance from the focus sought. Removal of the pia on the living brain leads to serious injury of the upper layer of the cells of the cortex, and even to their destruction, and in that way it interferes with results.

If chronic inflammatory changes are present on the cortex and meninges, such as scars, white infiltrated areas of the arachnoid along the vessels, etc., the Faradic tests are rendered more difficult and their results uncertain.

According to our experience, it must be said that in human

beings there is only one technique which insures a safe orientation, and that is electrical stimulation. All other methods, anatomical determinations made externally on the shaved skull, as well as localization according to convolutions and sulci, are generally undependable. Moreover, we cannot recognize the convolutions on the living as well as on the dead subject, because it is not permissible to strip off the pia, by which alone the furrows can be made to show up clearly.

The results which Krause has obtained by Faradic stimulation on the human brain are shown in Plate 83. All the foci which are found belong to the precentral convolution. They lie on the cortex, so arranged that the centers for the lower extremities are situated above, near the longitudinal sinus, and, as has been determined on experimental animals, they extend down on the median side of the hemisphere also. About the upper fourth of the precentral convolution is taken up with the lower extremity of the opposite side of the body. About half of the middle portion contains the foci for contractions in the upper extremity, from shoulder to fingers. In the lower fourth are situated the foci for the muscles of the face and the muscles of mastication; here the centers for muscles of the larynx, the platysma myoides and the tongue should also be found.

In a case of traumatic epilepsy caused by the blade of a knife penetrating the central region, we have observed isolated clonic contractions of the muscles of the belly of the opposite side, and we have seen the same symptom-complex in a tumor of the parietal and central regions. The center for the belly muscles has been found by Sherrington in apes to be between the arm and leg centers.

At the foot of the middle frontal convolution lies a center for the rotation of the head (Fig. 519, p. 529). Convulsions referable to this region may begin with rotation of the head, during which the eyeballs take the same direction; they forthwith involve the arm and the facial area, and then extend to become general.

Faradization of the cortex in man is not a trifling procedure, and when attempts at an exact limitation of the center sought for have to be continued for a long time, we have seen collapse develop, but this always disappeared after a short rest. Collapse is particularly likely to develop if too strong a current is used, or if even with a weak current the stimulation is continued for too long a time; in such case the utmost care is desirable. One should always begin with the weakest current and slowly strengthen it as needed by

shoving over the secondary coil of the sliding induction coil which we employ. In any case, one must be extremely careful with human beings, and should not continue the stimulation any longer than is absolutely necessary for the operative procedure. For, as surgeons, we are working not for physiological, but for therapeutic purposes. Accordingly, if one does not expect very definite and important determinations from Faradic stimulation of the cortex, which are necessary for the further course of the operation, it had better be omitted. In certain cases, as microscopic examination of the excised portion of the cortex showed, it has given rise to numerous fresh extravasations of blood of considerable extent into the meshes of the pia, and into the cortical parenchyma.

It must be observed, also, that the ability of the cortex to react to the Faradic current may become exhausted, with variable rapidity in different individuals, so that after repeated trials a focus which at first responded gives rise to no more contractions, or the contractions are seen to return only after a considerable rest.

EXCISION OF THE CORTEX IN THE ABSENCE OF VISIBLE ALTERATIONS

When the primary spasmic center has been exactly determined, excision of this region of the cortex is to be considered; this represents technically the simplest of all the procedures which involve the brain substance itself. The affected portion is excised as far as the medullary layer, that is to say for a depth of about eight millimeters. In order not to allow the field to be obstructed by hemorrhage, all the more important vessels which enter it are tied off. On the inner side of the line of incision, a second row of ligatures is applied, the long ends of which are used as a hold by which to elevate slightly the region of the cortex which is to be cut out; the incision is made between the long and the short ties. This technique is shown on Plate 84, Fig. 501; the pictures correspond to the following case:

A young man of twenty without nervous disease became ill at the time of eruption of his canine teeth, with gastric symptoms and slight fever. After an illness of four days, a severe general convulsion suddenly occurred in the afternoon, with loss of consciousness, which was followed by a temporary left-sided hemiplegia.

From the thirteenth year on convulsions had occurred at intervals of about a month. They began regularly in the left arm, ordinarily

Excision of the center in Jacksonian epilepsy.

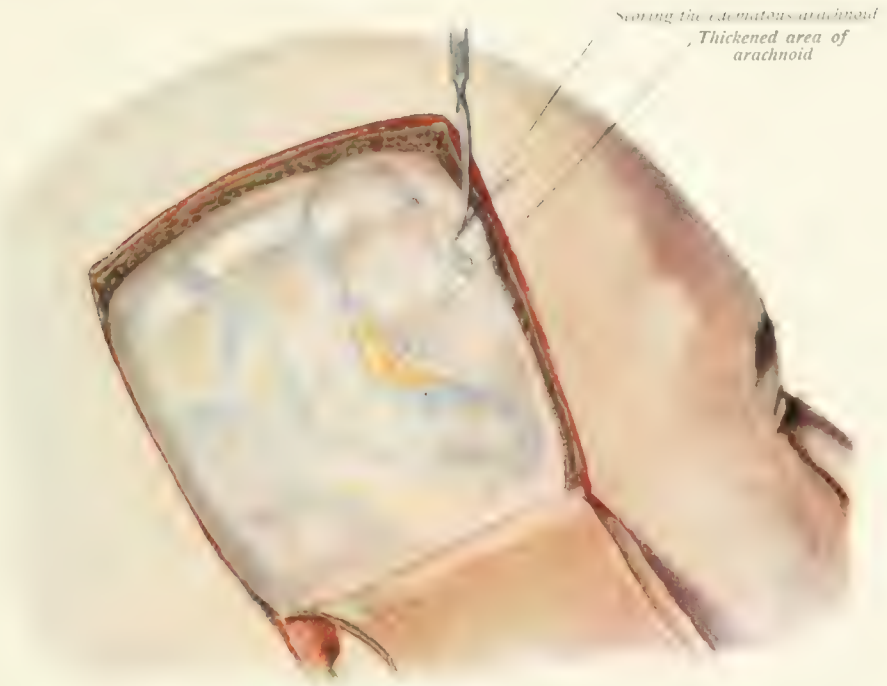


Fig. 500. Marked edema of the arachnoid.

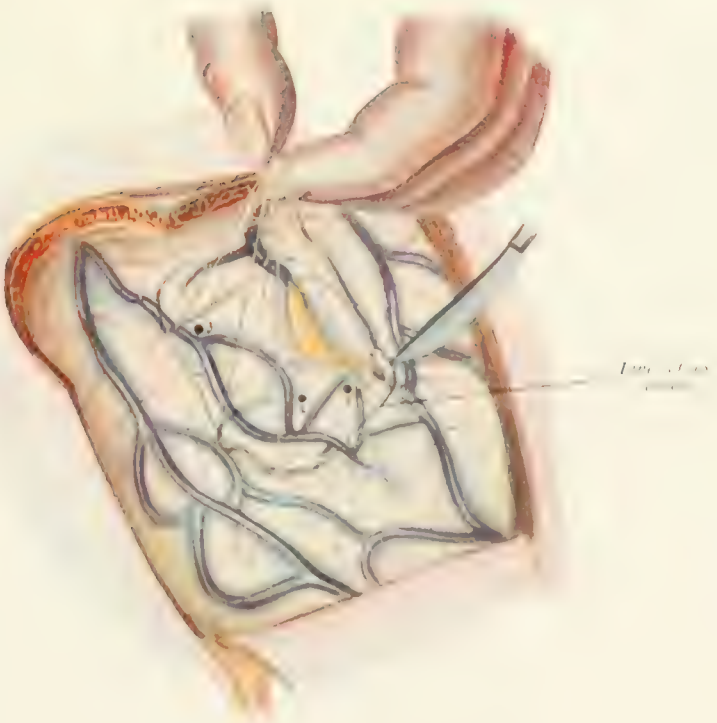


Fig. 501. Excision of the primary convulsive area

without disturbance of consciousness, and then developed into a rotation first of the head and then of the entire body toward the left. At times the convulsions occurred while the patient was standing. They lasted one-half to one minute.

As time went on the attacks increased in frequency, occurring almost every other day, and exceptionally as many as ten attacks would follow one another. Since the year 1900 they were ushered in by an outcry, and more recently by a cry of anguish; the consciousness now was almost always lost. Preceding the attack, the patient usually experienced pain in the left little finger, less frequently in the left thigh, and at times also in the right temporal region, and occasionally half-way between the shell of the ear and the upper region of the outer wall of the orbit.

The operation was carried out in two stages with an interval of six days.

As soon as the first incision was made in the considerably thickened dura mater (over one millimeter), the arachnoid protruded under strong tension and bulged like a tightly filled bladder over the entire length of the osteoplastic opening. As the dura was turned down in the form of a flap, the arachnoid presented a degree of brawny edema such as we have seldom seen. It protruded over the entire area (80 mm. square) of the large opening (see Fig. 500, Plate 84), and it was, moreover, covered with numerous white spots and nodules, which were particularly frequent over the pial veins. In one place, which according to its position must have corresponded to the precentral convolution, there was a yellow formation bent at an angle corresponding to the veins beneath it, with a length of 30 mm., and a width of 6 mm. Microscopically, this consisted of dense fibrous tissue.

In order to get rid of the edema so as to render the surface available for Faradic stimulation, the arachnoid was pricked along the entire lower margin of the wound. After a short time the picture of a normal cortical surface appeared (Fig. 501, Plate 84); at the site of the yellow formation a slight depression of the cortex was observed, and just above a slight bulging.

Faradic stimulation with a current barely perceptible to the tip of the tongue showed the following foci (see Fig. 501):

1. The left corner of the mouth is drawn strongly downward; contraction of the orbicularis oris, retraction of the left half of the lower lip upward and to the left.

2. The left corner of the mouth is drawn upward.

3. The left finger is abducted, clonic contractions of the forearm, ulnar flexion of the hand, contraction of the biceps; on a second attempt pronation of the hand and spreading of the fingers.

All foci were Faradizised three times in succession, and always yielded the same contractions. No reaction was obtained to the Faradic current in the yellow area.

Diagnostic punctures were undertaken to the depth of 4½ cm. at points two and three, but without result. Thereupon the primary spasmic area which had been outlined by the Faradic stimulation was excised, after first double-tying the vessels by passing ligatures about them on a needle, over an area in length 38, in width 30, and to a depth of 6 to 9 mm. The dura was replaced, and the osteoplastic flap was sutured in position without incident.

On awakening from the anesthetic the left arm was completely paralyzed, and the left lower facial distribution was strongly paretic; all other regions were actively mobile as before the operation. Four days later a change of dressings showed the wound healing by first intention. The general condition was good except that there was a certain amount of restlessness; no further attacks appeared. On the following day the pulse became slower and weak, so that stimulants had to be employed, which had not been necessary in the stage immediately following the operation. In spite of this the heart's action did not improve, and the patient died five days after the cortical excision with all the manifestations of cardiac insufficiency.

Autopsy (Prof. Östreich) showed the arachnoid clear, free of inflammation, and the sinuses not abnormal. In the right middle fossa the dura showed, on the inner side, a yellow-brownish discoloration. In front of this point the arachnoid of the right frontal lobe on its upper as well as on its median surface showed a grayish-white turbidity with a deposit of foci of the same color, which did not feel calcified. The same region showed a brawny edema and was colored a light yellow from the blood pigments. On the left side none of these changes were found, only there were a few small grayish-white nodules of the same sort in the sulci. Otherwise the arachnoid on the left was entirely clear. The entire arachnoid showed a moderate blood supply.

The right hemisphere, on the whole, appeared somewhat smaller than the left.

The thoracic and abdominal viscera showed nothing pathologic,

nor was there anything to show that the patient might have died during a convulsion.

After the brain was hardened in formalin and the pia had been removed, it could be seen that the excised section of the cortex, as well as the points of Faradic stimulation, were situated entirely on the precentral gyrus. The right cerebral hemisphere showed the picture of microgyrism. At the place of excision, there were small punctate and linear hemorrhages, which extended rather deeply into the medullary substances.

LIGATION OF VESSELS

Although ligation of vessels is essential, nevertheless, as the preceding observation shows, in spite of the minor character of the procedure, it does not always follow that it is unobjectionable. On the other hand the ligation of large vessels, particularly arteries, may involve serious disturbance to the tissue of the brain. To be sure, before extirpation of a tumor, all the afferent vessels about the focus should be carefully ligated. However only those which actually enter the area to be excised should be tied off, and, so far as possible, the main trunks should be avoided and only the branches ligated. In this manner the serious possibility of cerebral softening may be prevented. Once more a special warning should be offered against ligation of the internal or common carotid; their ligation almost invariably leads to edema and to extensive softening.

Horsley has shown that the arterial flow is from below upward; accordingly, the excision is begun below and proceeds upward toward the median plane. According to our experience, the incision in the brain should take no account of venous hemorrhage, for in the veins no definite course of flow can be demonstrated. In general the veins of the cerebral surface radiate outward from the longitudinal sinus.

RESULT OF EXCISION OF THE CORTEX

Excision of the primary spasmic center was taken up with enthusiasm under the leadership of Victor Horsley. But interest in it gradually died away and the procedure was soon given up, not altogether justly. In reviewing the literature, it will be seen that the majority of surgeons determined the center by anatomical landmarks, which, from our point of view, is not acceptable. Accordingly, all earlier operations in which this was done should be sub-

jected to a particular and searching criticism. Even after a large opening has been made in the cranium, we have found often enough that the center as determined by Faradic stimulation lay in a part hidden under the skull, and more bone had to be excised or a second bone flap made.

According to our experience there can be no doubt that extirpation of the section of the cortex in which the primary spasm occurs may lead to recovery in Jacksonian epilepsy, and for that reason we believe it to be a justifiable operation. Moreover, the danger of the operation is not increased by the extirpation of a small section of the cortex. We can state that the fatality which has just been related is an infrequent exception.

One gets the notion that only those processes which are located in the cortex itself, and accordingly are within easy reach, are to be considered in excision of the spasmic center. This, however, is not always the case. Even if the epilepsy originates in a focus of disease which lies deep in the brain substance, a favorable influence may be exerted by the operative procedure on the cortex, and indeed a lasting cure may result, as our experience has shown.

In any case, after excision of the cortex a definite loss of function appears, which increases for a certain period, and then decreases. If the excision does not comprise too large an area, that is to say, at the largest, 30 mm. in length, 24 mm. in width and 8 mm. in depth, the paralysis and sensory disturbances disappear in the course of days, weeks, or months, some sooner and others later. They do not disappear entirely, however; in many instances there remain isolated defects in the finer movements, which ordinarily cause no significant symptoms.

In the cortex which has undergone more or less change as the result of cerebral paralysis of infancy, even extensive excision is not followed by lasting disturbances; in these cases, therefore, the method may be employed without reservation. However, in cases in which the cortex shows macroscopically normal conditions, one should be particularly careful, excising only the smallest area, as otherwise a post-operative paralysis or paresis may remain behind. This caution should be particularly emphasized on the left hemisphere on account of the center of speech and the importance of the extremities of the right side.

OPERATIVE PROCEDURE IN JACKSONIAN EPILEPSY FOLLOWING CEREBRAL PARALYSIS IN INFANCY

In the category of Jacksonian attacks, the number of those patients who have become epileptics as the result of cerebral paralysis in infancy is in the majority. This disease develops on the basis of encephalitis or meningo-encephalitis. In acute encephalitis, at first large sections of the brain are affected with the disease, which ordinarily, if not always, is of an infectious character. The resemblance to infantile paralysis (acute anterior poliomyelitis) cannot be gainsaid. For instance in this condition, with its accompanying manifestations of an acute infectious disease, extensive areas of the body are frequently at first sympathetically affected. Then restoration of active movements shows itself in many muscle groups, but the regions of which the large ganglion cells in the anterior horns have been destroyed remain permanently paralyzed. Anterior poliomyelitis may occur in association with encephalitis, or the two diseases may be observed in the same individual at different times.

In acute encephalitis, the accompanying symptoms include a general convulsion, unconsciousness, and high fever; then paralysis of one limb or a hemiplegia occurs, with or without paralysis of the face; sometimes with strabismus, and even with more extensive disturbances. In the further course of the disease, certain areas recover, and finally, often paralysis of one arm or leg or of one section of the limb alone, persists. Disturbances of speech occur, particularly if the affection is located on the left side; moreover speech, which has already developed in a child, may become completely lost again. The child recovers from the acute disease, except for the loss of function, and it is only after months and years (we have seen the interval as long as sixteen years) that convulsions arise in the paretic limbs.

The nature of the irritation which gives rise to the convulsions cannot in many instances be determined. It may depend upon the finest molecular changes in the ganglion cells, which will always remain hidden from our observation, just as we must give up expectation of ever being able to observe the process that takes place in these cells on thinking and acting, on sensation and movement, but which, nevertheless, have to be postulated. In such cases of

Jacksonian epilepsy the exposed area of the cortex appears to us normal.

At other times visible changes are present, such as arachnoid processes, scars, cysts, upon a meningo-encephalitic base, which may be located within or below the cortex. Several such cysts may be present in the same patient, as Fig. 502 shows. The sagittal line is represented by the dotted line. This was the case of a twelve-year-old girl who suffered from encephalitis at the age of three, following a severe febrile dysentery. When she was eight epileptic

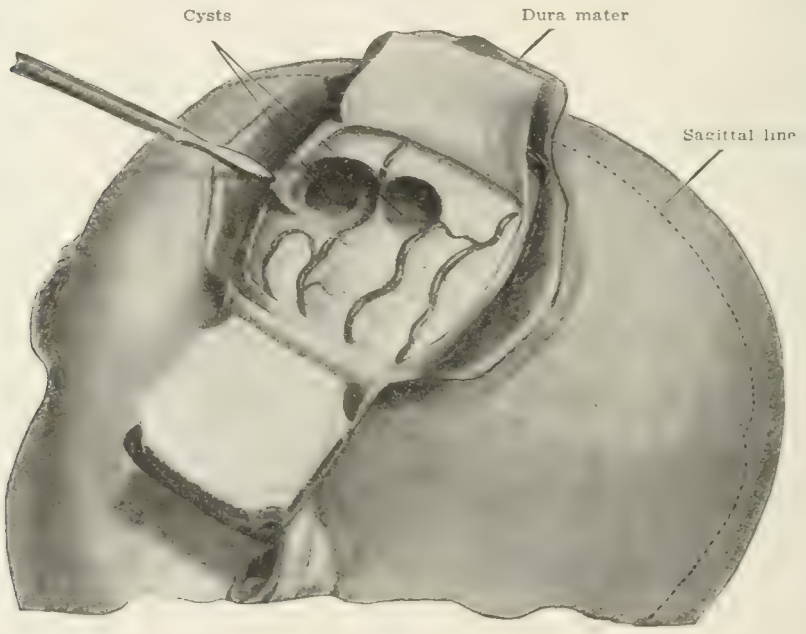


FIG. 502
Brain cysts in a case of Jacksonian epilepsy.

attacks appeared, which thrust the paralysis of a segment of the lower extremity completely in the background.

In short, in such pathological conditions one should predicate the cause of the convulsions, and if possible remove it. As a sign of an old preceding inflammation, the cranial bone is often found unusually thick; for instance, the ordinarily thin bone of the temporal fossa has measured over one cm. through in a young woman twenty-four years old.

As etiologic factors in encephalitis or meningo-encephalitis, there may be mentioned, according to our experience, scarlet fever, diphtheria, whooping-cough, dysentery, influenza, pneumonia, erysipelas

Cystic degeneration of the lateral ventricle.

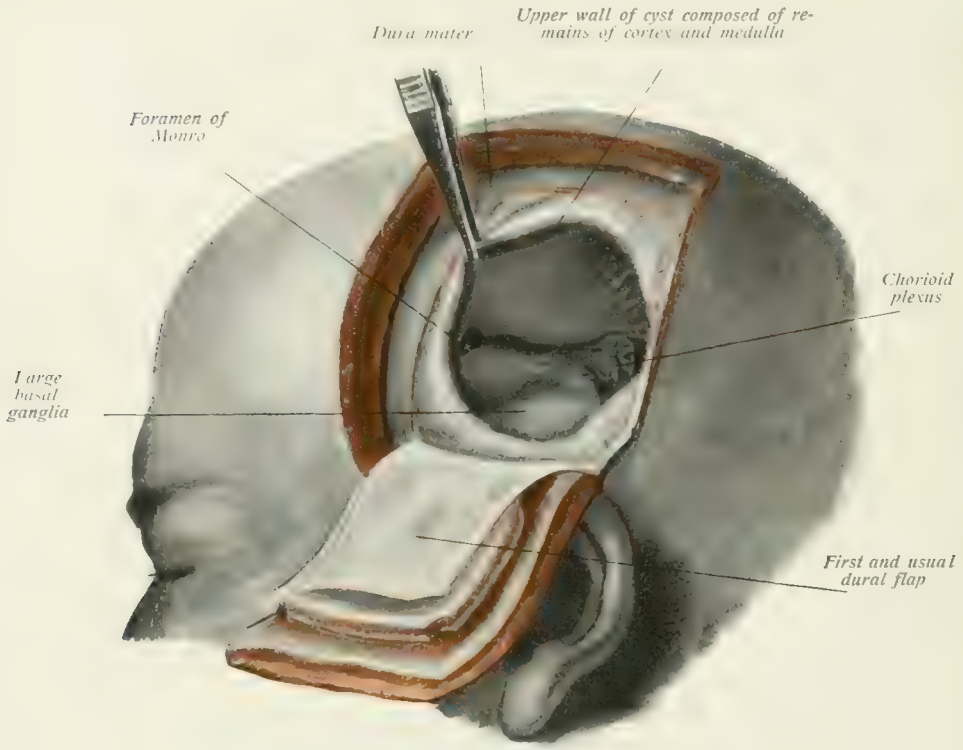

Dura mater
Upper wall of cyst composed of remains of cortex and medulla
Foramen of Monro
Chorioid plexus
Large basal ganglia
First and usual dural flap

Fig. 503. Lateral ventricle, widely exposed.

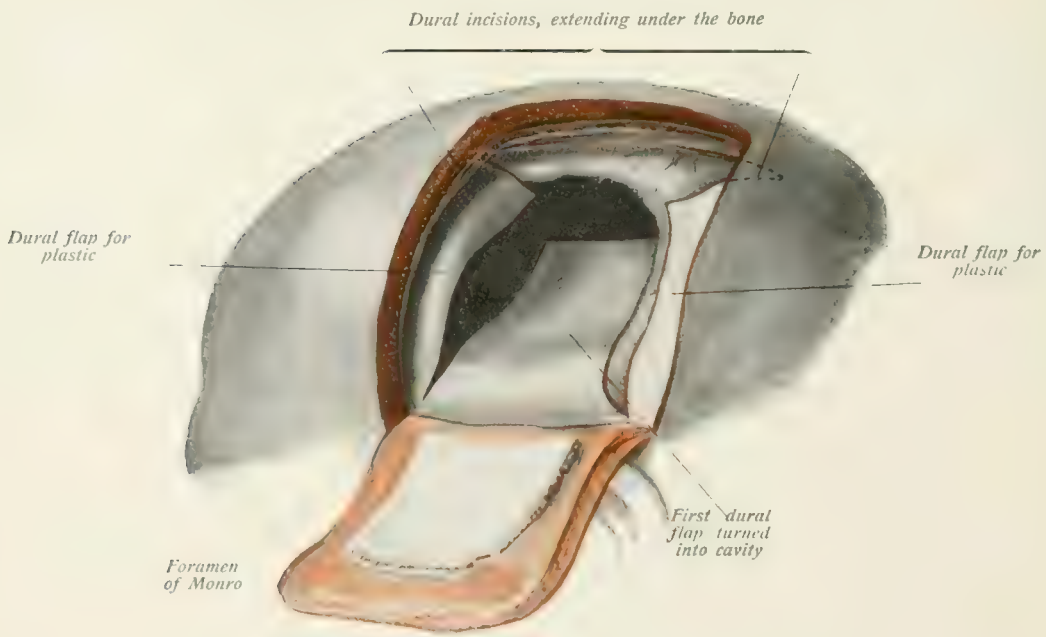

Dural incisions, extending under the bone
Dural flap for plastic
Dural flap for plastic
First dural flap turned into cavity
Foramen of Monro

Fig. 504. Dural plastic, for covering the cystic lateral ventricle.

after vaccination, and heat stroke; syphilis may also give rise to Jacksonian epilepsy. Cerebral paralysis may also result from injury to the brain during delivery; a direct crush of the central region by forceps, or a trauma of longer duration during the second stage of labor in unfavorable conditions of the pelvis or in case of disproportion between the head and the pelvis may thus endanger the brain. We will show immediately a characteristic example. Finally asphyxiation, occurring in difficult labors, must be looked upon as of etiologic moment. Just as we have often observed large hematoma of the cranium, so, in cases of severe labor, hemorrhage will similarly occur between dura and brain or in the brain substance itself. Virchow has shown that the large veins entering the longitudinal sinus may be pulled away just at their point of entrance.

CYSTIC DEGENERATION OF THE LATERAL VENTRICLE

A ten-year-old girl came into the world asphyxiated after a difficult labor, and immediately showed a right-sided hemiplegia. In the ninth year, that is to say nine months before we saw her, convulsions appeared; they always began in the right side of the body and then became general. Intelligence and speech were very defective.

The right arm and leg did not show a marked retardation in development, and were only slightly atrophied. In the right arm there was a pronation contracture which could be overcome only with difficulty. The hands and fingers were rather hypotonic. In excitement the fingers acted almost as in tetany. Motion of the right arm was limited to the coarser movements in the shoulder and elbow joints. The patient could not use the right hand for gripping. In walking the right leg was dragged in equinus; there was an equino-varus deformity. In the right arm and leg spastic reflexes were obtained. On the right leg the tendon reflexes were increased; the Babinski sign was present on this side, but not on the other. The diagnosis, made by Oppenheim, was right spastic infantile hemiplegia, the ordinary picture in cerebral paralysis of infancy, with epilepsy.

On May 24, 1911, as the first step in the operative treatment, a large trap-door was formed in the typical manner over the left central region without opening the dura. The second stage was performed on June 2, 1911. After the dura was turned down in the form of a flap (Fig. 503, Plate 85), a large cyst appeared in

the middle of the operative field, which was covered only by a thin bluish translucent membrane, and which extended from above downward 55 mm., and transversely at the widest point 30 mm. Accordingly, the entire exposed motor region appeared like a bladder which was filled to the bursting point. There was no increase of pressure, nor did the brain protrude in the least into the bony opening.

Upon puncturing it with a paracentesis needle the fluid content of the cyst did not spurt, but it ran out very slowly drop by drop. The thin protecting layer of tissue was excised wherever it was very thin and preserved for microscopical examination. The report of this examination (Prof. Östreich) was as follows: Wall of lateral ventricle; remnant of cortex. Simple proliferation of ependyma; few calcified areas, few psammoma bodies, nothing specific.

After a large quantity of absolutely clear light yellow fluid had run off, the lateral ventricle lay widely opened. It was recognized from the structures which lay exposed in the large cyst, namely the choroid plexus and the enlarged foramen of Monro, as well as from the shape of the large ganglia which projected on the floor of the cavity. One could also clearly observe how the fluid was being continually pumped synchronously with respiration from the right ventricle through the foramen of Monro into the cavity. The floor and the medial wall of the lateral ventricle were thus freely accessible. The cavity, measured from the surface of the brain toward the middle line, was 60 mm. deep; vertically from above downward, 50 mm.; from before backward, fully 50 mm. In order that no blood could run into the right ventricle during the further manipulations, gauze was introduced into the foramen.

To close the large cavity by obliteration, its external wall had to be mobilized, and for this purpose the following technique was employed (Fig. 504, Plate 85). An additional finger's breadth of bone was removed from the margin of the opening in front and behind, so that later the bone and tissue flap would sink inward sufficiently. Then the dura at the anterior and posterior margins of the wound was freed up from the inner table for one cm. more than corresponded to the enlarged bony opening, so that a wide strip of dura was obtained in front and behind. This flap of dura, intended for plastic purposes, was divided sagittally in front and behind along the upper margins of the osteoplastic opening to the limit of the separation of dura from skull. At the lower margin

of the opening a small oblique incision in the dura had been made in front and behind when the flap was first formed; these small flaps of dura could be turned in without difficulty against the corresponding surface of the lateral ventricle. The base was entirely covered by turning in the large lower dural flap. However, a considerable area of the medial wall of the ventricle remained uncovered by dura, particularly above. Regardless of this, the bone and tissue flap was replaced in its original position and sewed in without drainage by interrupted sutures.

The dressing, in order to maintain asepsis so far as possible with the expected profuse flow of cerebro-spinal fluid, was applied in the following manner: A thick layer of vioform gauze was first applied; this was covered with an ordinary sterile dressing and held in place with a sterile bandage. Over this thick layers of iodoform gauze were applied, which were changed whenever they became soaked with fluid, while the inner dressing was not disturbed. The event showed that the upper layer had to be renewed every day on account of the copious flow of fluid.

On the 9th of June the entire dressing was removed for the first time, and reapplied just as after the operation. The bone and tissue flap was found sunken about one-half cm. below the level of the skull. It pulsated slightly. The wound edges showed no signs of irritation and the sutures were removed. There had been no rise in temperature, nor did any rise appear later on in the course of convalescence. Variations of pulse of any account could not be demonstrated, even though just after operation the pulse-rate rose one evening to 130. Potassium bromide was given twice a day, to prevent so far as possible convulsions arising as the result of the traumatic irritation of the brain, and in this it was entirely successful.

Until the 9th of June the general condition of the child remained unchanged, except for slight pains in the region of the wound. From that time on increasing exhaustion and irritability were apparent. Incontinence of urine and feces developed; the extremities were cold to the touch and painful on the slightest movement. The flow of cerebro-spinal fluid gradually diminished, and on the 18th of June the flap buckled out without showing pulsation. At this time the wound edges were closed except for an area the size of a pea in the posterior upper corner, from which the clear fluid issued in small quantities drop by drop. The apathy

of the child reached its height on the 20th of June, but from that time on the general condition gradually improved. His interest in his surroundings increased, and by the 1st of July he had regained control of bowels and bladder, the pains in the extremities had diminished, movements of the left arm and leg were free, and in the right clumsy but strong.

There was no change in the condition of the wound and of the secretion, but a bedsore the size of a quarter dollar appeared on the external occipital protuberance, which required several weeks for healing. By the middle of July the flow of fluid had ceased, the wound was entirely closed and dry, and on July 21st the child got out of bed for the first time.

By August 9, 1911, the child was much more active mentally. In a comparatively short time he had learned the German language, which showed the possession of a considerable amount of intelligence. Motions of the right arm were good, but those of the hand were less so, and there was lacking in particular the power of uncombined movements of the fingers.

On testing the sensibility it was found that moving a brush back and forth could be felt, but that it was mistakenly localized. There was no interference with walking except as the result of the deformity of the foot. Without question the operative treatment had exerted a favorable influence on the child not only in the psychic, but in the motor functions as well.

The child was discharged home. According to a letter from the father, dated March 2, 1913, the cure of the convulsions had remained permanent. The paralyzed hand had improved so much that the child could use it to work with.

The case just described was one of a large hydrocephalus limited to the left lateral ventricle, but which had not induced the slightest symptoms of increased cerebral pressure. Its development, in all probability, is to be referred back to an extravasation of blood into the brain or into the lateral ventricle, with the subsequent development of an inflammatory process. The partition which had probably been originally present between the individual hemorrhagic cysts and the lateral ventricle disappeared as the result of pressure and the inflammatory changes, and finally this great cavity was left behind, which, covered by a thin external wall, corresponded to the enormously enlarged lateral ventricle. That chronic inflammation

had taken place was established by the microscopic examination. An isolated hydrocephalus of one lateral ventricle at no time accompanied by general symptoms of increased intracranial pressure, as in this case, would have caused an extraordinary thinning, in fact an almost complete disappearance, of the lateral wall. Such internal pressure is contradicted also by the condition of the interior of the ventricle, the structures of which showed not the least evidence of flattening in their form.

Healing of so large a cavity could only result through obliteration. The operative procedures which were necessitated by the conditions found were directed toward this end. In fact, the implantation of the three dural flaps on the medial wall of the ventricle and the turning in of the bony flap, whereby over a certain area the inner surface of the bone came to lie directly upon the lining, and the nerve substance of the lateral ventricle, resulted in healing. Puncture and aspiration alone would never have accomplished a cure.

Von Haberer, in a case similar to the one above described, in which, however, there was not sufficient dura for plastic purposes, excised a large flap from the fascia lata (see the heading, Plastic Restoration of the Dura Mater, p. 694), and laid it upon the open lateral ventricle. The free edges of the fascia were introduced under the margin of the bony opening, and were there united by widely separated sutures of iodized catgut to the dura, which could be isolated from the mass of scar tissue only at the edges of the bony opening. The result showed that fascia could be used for covering in an open ventricle.

The conditions were rather more difficult than in the ordinary form of dural plastic. Here the free portion of fascia is laid upon a well-nourished base, the normal brain surface, or brain surface freshened by scar excision or extirpation of tumor, while in Haberer's patient the fascia rested upon the fluid of the lateral ventricle and found its nourishment from the margins, as the covering flap of skin was also in the greater part composed of scar tissue.

FORMATION OF BONE IN THE DURA OVER THE CENTRAL REGION

The following case shows the difficulties in operating which may be offered by pathological changes.

In a patient not quite eighteen years of age, convulsions had occurred since the fourth month, without having been preceded by

demonstrable disease or known trauma. In the first year they were infrequent and mild. The convulsions themselves were short, and sometimes a year or more apart, so that the patient had developed well in mind and physique. Intercurrent diseases, such as measles and osteomyelitis of the os calcis, were followed by a temporary disappearance of the convulsions. In the last few years, however, the intervals between the attacks had been shorter. The convulsions grew more and more numerous, and they occurred as often as seven times in one day. The patient was completely deficient in will-power and was so dependent that he could not even dress and undress himself.

In the beginning of the attack the head and eyes were always twisted violently to the right, and then the right hand was involved in the spasm, before the convulsion became general. We were accordingly justified in inferring that the originating impulse for the convulsion emanated from the foot of the middle frontal gyrus (see Fig. 519, p. 529) in the left central region.

The operation was performed in two stages. At the first stage the soft parts were incised in the ordinary manner over the left central region, and two drill holes were made in the upper corners of the wound. The attempt to loosen up the dura from the inner surface of the skull by means of the Braatz guide through the posterior drill hole was unsuccessful, in spite of the application of considerable force; however, it was possible for a distance of 1 cm. forward through this drill hole. From the anterior drill hole the procedure offered no difficulties. Then we were able to incise the bone with the Dahlgren forceps and to break it back in the ordinary fashion.

Corresponding to the upper two-thirds of the posterior bony incision, the dura was found to be torn to the extent of 5 cm., and beneath this tear there lay a large, irregularly formed plate of bone. In order to expose the entire plate, a strip of bone about 2 cm. wide had to be broken away with rongeurs below and posteriorly, so that the osteoplastic opening was ultimately 7 cm. wide and 8 cm. high.

As the second stage of the operation, which was undertaken a week later, the dural flap was incised and turned down (Fig. 505, Plate 86). The bony plate appeared, roughly speaking, shaped like a kidney, with irregular borders, and measured from before backward 43 mm., and from above downward 63 mm. On its ex-

Subdural formation of bone in the central region.

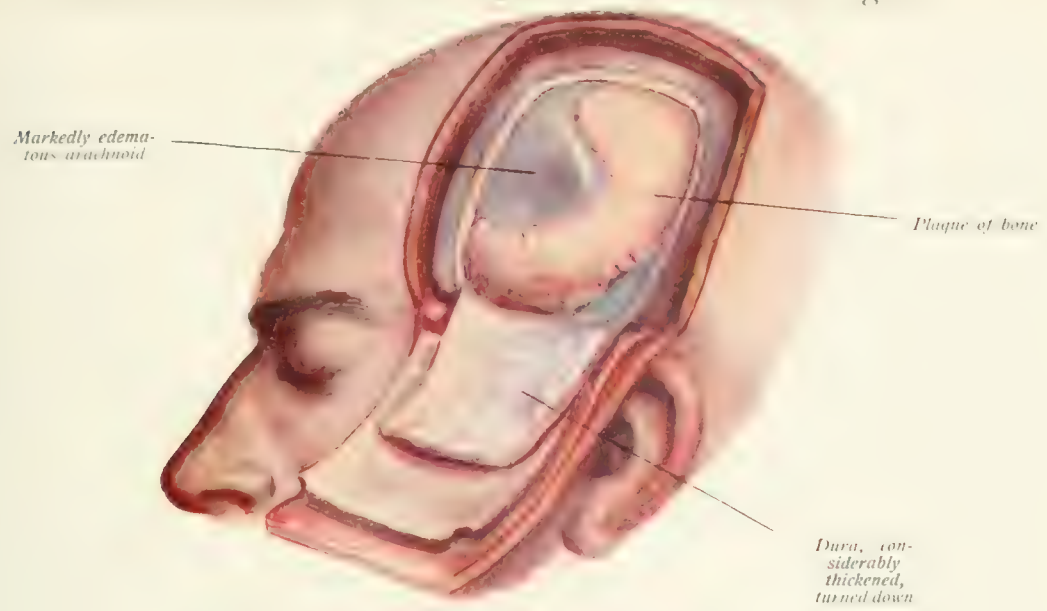


Fig. 505. Exposure of the central region.

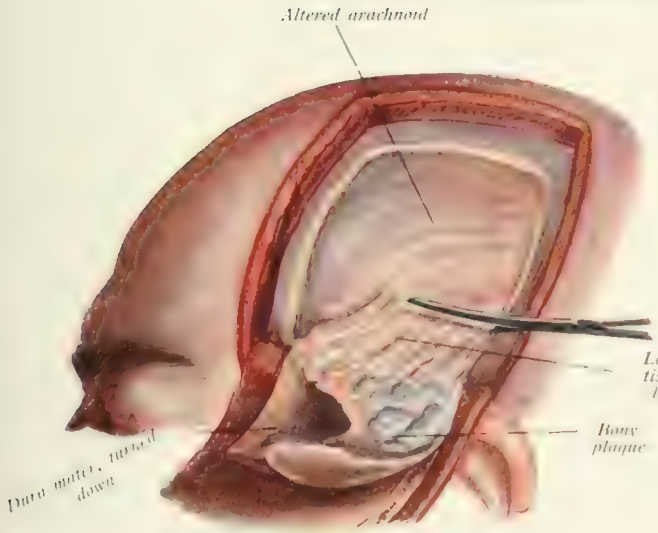


Fig. 506. Excision of the bony plaque.

Fig. 507. Bony plaque, inner aspect.

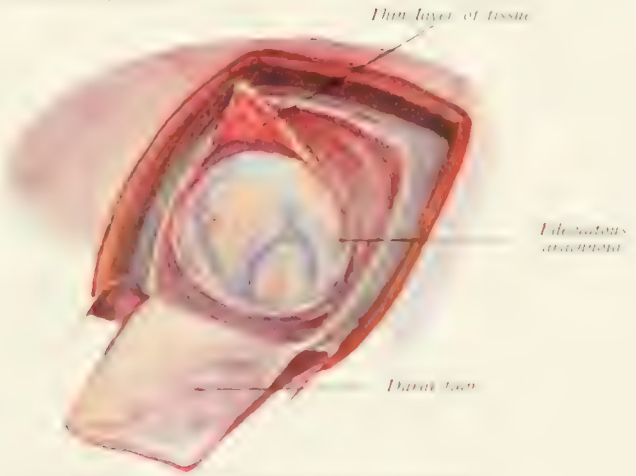


Fig. 508. Removal of the altered arachnoid.

ternal surface it was fairly smooth and of a yellowish-red color. In order to remove it, a thin scarlike membrane had to be carefully divided around its margin with a knife, taking care to protect the underlying arachnoid. Then we were able to lift the upper portion of the plate with the fingers and to divide another thin membrane, which represented the innermost layer of the dura, with scissors, and finally to cut it away altogether (Fig. 506, Plate 86). The plate of bone at the margin was about one-half millimeter thick. The inner surface over the larger portion showed bluish-white nodules the size of a bean, which ran up to 6 mm. in thickness (Fig. 507, Plate 86).

After removal of the bony plate and the thin layer of tissue, the markedly edematous arachnoid came into view (Fig. 508, Plate 86). It appeared considerably thickened, particularly in the neighborhood of the vessels. On pricking it and on repeated excision of bits of the outer layers of the arachnoid, a considerable amount of fluid trickled out. After the dural flap was scraped and smoothed off on its inner surface, it was turned back upon the brain, the bone and tissue flap was sewed in without drainage, and the hemostatic suture removed.

As the dressing remained dry, it did not have to be changed for ten days. The sutures were then removed, and a protective dressing applied for eight days more. Temperature and pulse showed no abnormalities. The patient received bromides for the first four weeks, in order to weaken so far as possible the effect of the operative irritation on the central region. During this entire time no attacks appeared. Three weeks after the second operation the patient left the bed, and two days later journeyed back to his home.

During the next five months, only very infrequent and light attacks of a general form were observed, without indications of the earlier cortical type. Then they became more frequent for two months, and then again became infrequent. The patient had intervals as long as two months during which he was free of attacks, and then again there were times when attacks appeared every two or three weeks, but these attacks were much lighter and of shorter duration than those preceding the operation. The general condition had improved correspondingly.

As regards the origin of the convulsion, it is evident that a formation of bone with so irregular an inner surface may exercise

a strong irritative action upon the central region. The history gave us no data as to the basis of disease upon which the bony proliferation developed; naturally it must have been some inflammatory affection of the meninges, for the bony plate lay under the dura or at least under its chief layers, and apparently we had to do in this case with a pachymeningitis ossificans.

SUPERFICIAL CYSTS OF THE BRAIN AFTER OPERATION ON THE MIDDLE EAR: OPENING AND PLASTIC COVERING ON ACCOUNT OF EPILEPSY

It is not alone disease and injury of the central region which leads to epilepsy; these conditions may cause it in other portions of the brain. To be sure the further the lesion is removed from the central region the less frequently does epilepsy occur. For that reason the frontal lobe is of great importance, and next the parietal lobe. If any changes are found which can be considered as exerting causal influence, they must be removed by operative means.

A young woman of twenty-four years had developed at the age of five a left purulent otitis media, following an injury to the external auditory meatus—the child had stuck peas into its ear. In 1890 an operation was performed for this condition. While the child developed normally after the wound had healed, in the sixteenth year attacks of faintness suddenly developed, which a few weeks later went over into general convulsions of the epileptic type, and repeated themselves at intervals of days to months. At the age of nineteen years (1907) an inflammation of the middle ear developed again upon the same side with high fever, making a second operation necessary. The fever and the purulent discharge then disappeared, but the attacks remained.

When the patient came under our observation in 1909, her chief difficulties consisted in severe headache and infrequently occurring convulsive attacks without definite character, which were followed by a long period of unconsciousness. Above and behind the left ear there were extensive scars (Fig. 509, Plate 87). On palpation one could feel a bony defect 40 mm. wide and 48 mm. high, in which region pulsation of the brain was clearly visible.

During the attacks, the brain substance projected markedly at this place. As a favorable influence upon the epilepsy is sometimes obtained by a bony closure of such a defect, it was planned to close this bony opening by a König-Müller plastic.

Cyst following an old mastoid operation, I.

Fig. 509. Incision for removal of scar.

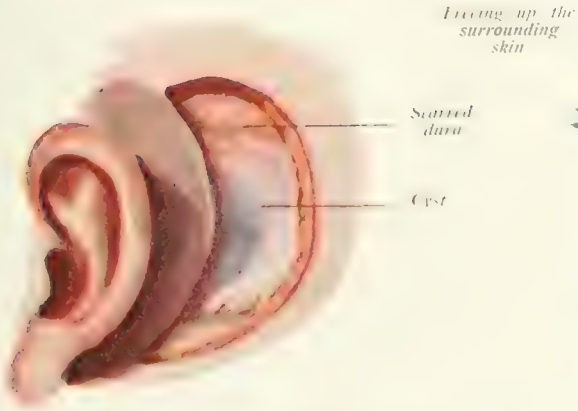


Fig. 510. The cyst exposed.

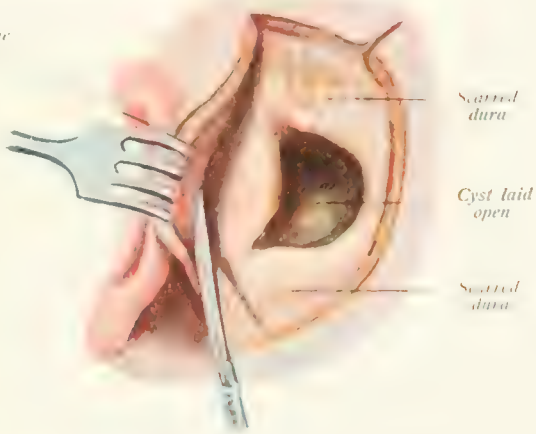


Fig. 511. The cyst opened.

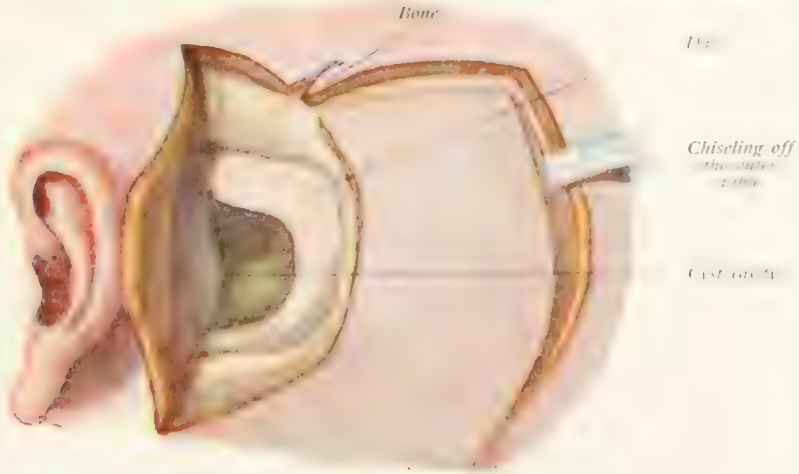


Fig. 512. Making the osteoplastic flap.

König-Müller plastic for covering the cyst cavity, II.

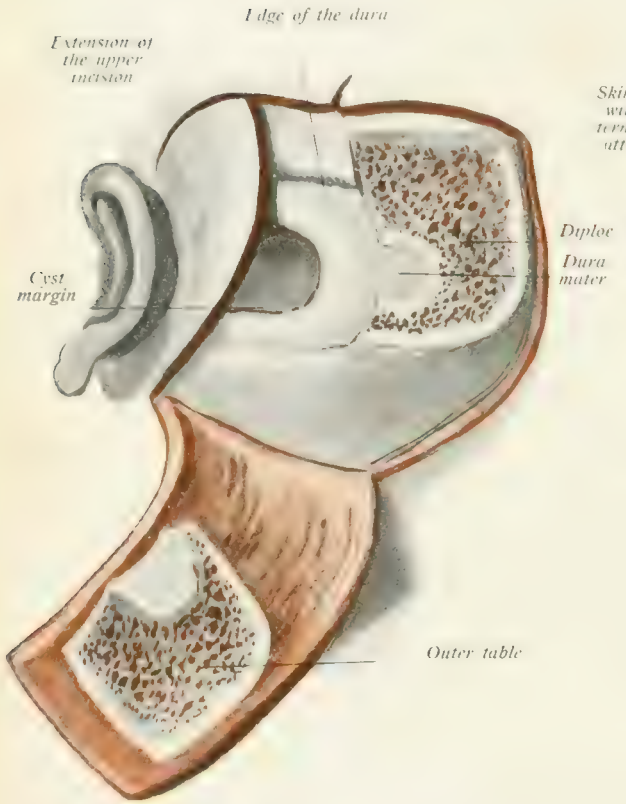


Fig. 514. The osteoplastic flap is turned down.

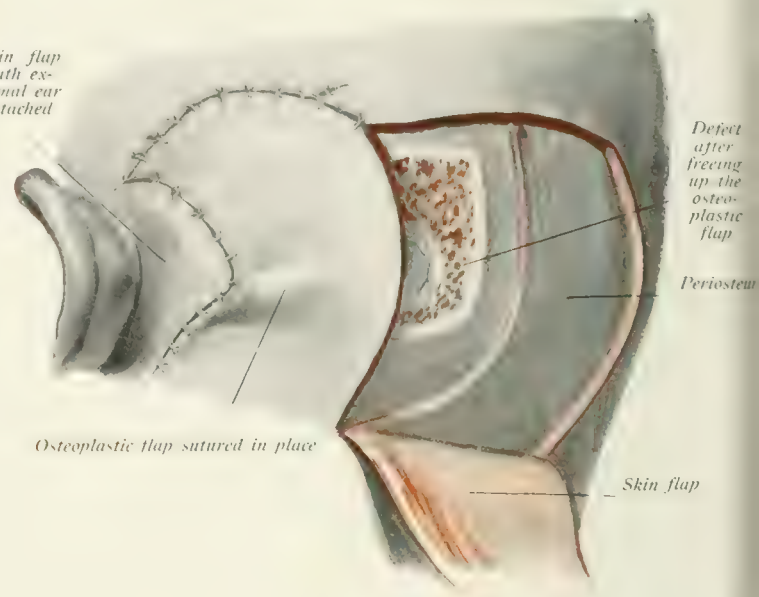

Skin flap with external ear attached
Defect after freeing up the osteoplastic flap
Periosteum
Osteoplastic flap sutured in place
Skin flap

Fig. 515. The first flap is sewn in, and a second is formed, consisting of skin only.

Fig. 516. Implantation of the second skin flap.

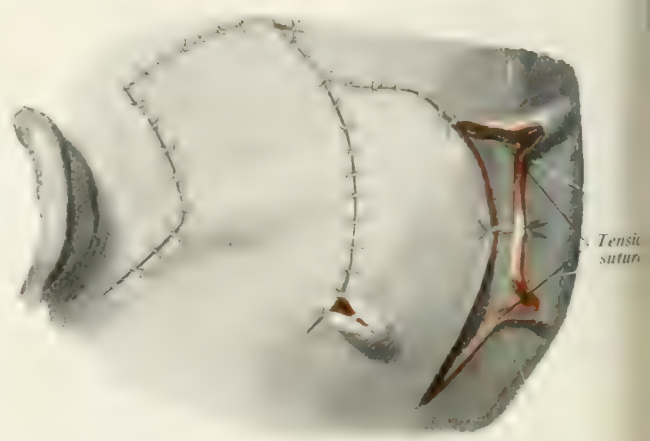


Fig. 517. The remaining defect is lessened by tension sutures.

After the application of a hemostatic suture according to the method of Heidenhain, over an area so large as to include all the visible incisions, the wide scar under which the palpable defect of the skull extended was excised (Fig. 510, Plate 87). Under this very tough scar was found a cyst filled with clear fluid; the layer of tissue which covered this cyst—which further examination showed was evidently the transformed dura—was so thin that the watery contents showed up through it with a bluish color.

Upon removal of this membrane there was found in the brain substance a hole the size of a cherry, the wall of which was formed of yellow brain substance, which looked like fat (Fig. 511, Plate 87). Three veins which were bleeding badly had to be tied off with catgut passed about them on a needle. In order to expose the defect completely, the skin was dissected off from the periosteum all about it with a knife, and the scar tissue was everywhere completely excised. The bony defect measured 42 mm. across from side to side and 48 mm. from top to bottom.

In order to close this defect with bone, a plastic flap was cut with its pedicle below in the following manner (Fig. 512, Plate 87). Starting from the upper margin of the defect, a slightly curved incision 4 cm. long was made upward and backward, and was then continued downward behind and parallel to the posterior margin of the defect. The periosteum was freed from the skull for a short space above and behind. Then beginning at the upper margin of the flap, the outer table was cut away with a Küster bayonet chisel. The process was continued in the same way at the posterior incision, until the outer layer of bone was separated over an area 30 mm. wide and 40 mm. high (Fig. 514, Plate 88).

On account of the thinness of the bone, the dura was exposed at one point, so that the bony flap here contained the entire thickness of the skull, which was only a few millimeters. In order to further mobilize the flap, the posterior incision was lengthened downward and somewhat medially, and the periosteum on the pedicle of the flap was freed up from the skull with a raspatory. Then the flap containing skin, bone, and periosteum could be applied over the defect in such a way that the bony plate fitted into it exactly.

When this was accomplished there was found to be an excess of skin in front in connection with the shell of the ear, while on the concave side of the flap the skin was insufficient. Then by lengthening the upper incision in a curved manner several cm.

toward the shell of the ear and dissecting up the skin from the periosteum, we were able to obtain a new skin flap which could be carried without tension downward and placed in the defect which remained in the anterior concave margin of the plastic flap, so that it filled it completely. This flap, as well as the upper margin of the skin and bone flap, were sewed exactly in their proper places with interrupted sutures (Fig. 515, Plate 88).

Behind the displaced plastic flap there was now left a crescentic defect measuring 30 mm. wide at the middle and 80 mm. high.

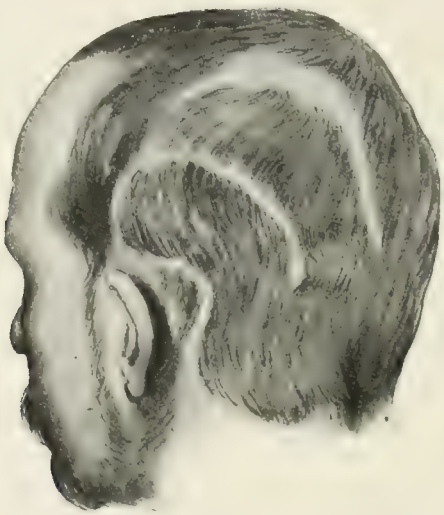


FIG. 513

Condition eight weeks after plastic by the König-Müller technique.

In closing this care had to be taken that no tension of any sort was exerted on the osteoplastic flap from behind, which would exercise a harmful influence on its nutrition. Accordingly a tongue-shaped flap, with its pedicle below, was cut out behind and freed up from the periosteum with a knife (Fig. 515); below, however, at the pedicle the periosteum was included in the flap for its better nutrition. This was then sutured behind to the osteoplastic flap (Fig. 516, Plate 88), with the formation of a pucker at the anterior lower corner of the wound.

The defect which still remained behind could be decreased in size by dissecting up the skin behind it from the periosteum, and by taking a horizontal tuck above and one below so that only the slightest pull would be exercised on the plastic flap itself. The

posterior wound margin, by this procedure, was brought so close to the second skin flap and was so freely movable that a suture could be placed in the middle of the small defect without the least harmful tension being exerted. There remained finally only a defect 14 mm. wide and 60 mm. high, in the floor of which the periosteum of the skull was retained (Fig. 517, Plate 88).

The wound healed by first intention without marginal necrosis of the flap; pulse and temperature showed no noteworthy fluctuation. On the eighth day the dressing was changed for the first time, and most of the sutures were removed; the three stitches in the posterior defect were taken out a week later after they had begun to cut through. By this time the defect had become notably smaller and it presented a good granulating surface, which was touched every four days with caustic. Four weeks after the operation the patient was discharged to the out-patient department; a month later the defect also had scarred over.

As for the epilepsy, the attacks continued during the first four weeks after operation. Then they became fewer in number and in severity, but they never ceased entirely. In January, 1911, hemorrhoids which had existed for several months caused severe symptoms; in July the patient was operated on and a cancer was found situated high in the colon. Following this operation the patient died.

CHAPTER 20 — SURGERY OF BRAIN TUMORS

GENERAL SYMPTOMS OF CEREBRAL COMPRESSION

Every pathological mass within the cranial cavity, whether neoplasm, abscess, cyst, or collection of blood, in any section of the brain or its surroundings, or an accumulation of hydrocephalic fluid, induces, as soon as the restriction of space has reached a certain degree, manifestations of increased intracranial tension. However, it is surprising how high a degree of encroachment the brain may at times become accustomed to, provided the limitation has been a gradually increasing one, without the appearance of any symptoms whatsoever. Of this we might be able to give numerous examples.

HEADACHE

The manifestations of increased intracranial tension are collectively called the general symptoms of cerebral compression. Headache is practically always present, and it may reach the highest degree. In cases of cerebral tumor it is likely to be vague, embracing the entire head, or it is located upon the forehead, or in the eyes, or in the occiput, or in the back of the head; but even when limited to a small area it need not necessarily correspond to the location of the tumor.

As a rule headache must be classified with the general symptoms. It can only be considered a local phenomenon when it is always experienced, either spontaneously, on pressure, or on percussion, in the same place on the skull. This, however, is not frequently the case in brain tumors. But if the dura is also involved, the pain is more likely to be localized at the site of the neoplasm.

Headache is occasionally accompanied by *nausea* and *vomiting;* these symptoms, however, may occur by themselves without other manifestations in brain tumors. Vomiting is absent in more than half the cases. Cerebral vomiting is characteristic in that it may occur upon the fasting stomach, and is not followed by retching; it sometimes arises without provocation in a projectile form.

PSYCHIC DISTURBANCES

Any process which leads to a crowding of the structures within the skull may lead to severe psychic disturbances, such as weakness of memory and torpidity; the latter may develop into unconsciousness or stupor. That the cerebral compression, at least in a series of cases, may represent the cause of the symptoms is proven by the favorable results which follow the relief of tension by osteoplastic opening of the skull without opening the dura, the so-called decompression operation. If the focus of disease can successfully be removed, we may, if the stupor has not existed for too long a time, see a return of the psychic faculties, often within a surprisingly short time, twenty-four hours or so, or at least the beginning of a considerable improvement in the psychic state. In cases which show such rapid restoration of the faculties, there cannot be present any gross anatomical changes.

A considerable increase in the intracranial tension may bring about general convulsions. Vertigo also plays an important part in this connection. A general dizziness manifests itself in a loss of equilibrium. For the circular vertigo which is characteristic of increased tension in the posterior fossa, see page 590.

CHOKED DISC

Of the greatest importance as a symptom of general increase in intracranial tension is choked disc. It represents so characteristic a manifestation of increasing cerebral compression that its presence or absence may be decisive for diagnosis. It may not be present in every case; it may be found with small tumors and be absent with large ones, and its intensity bears no proportion to the size of the tumor. The site of the neoplasm plays an important part in its occurrence. It occurs earliest in cases in which the large veins are directly subjected to pressure, and with the sort of cerebellar tumor which crowds the space in the posterior fossa between the tentorium cerebelli and the skull itself, and interferes with the return flow of blood. In these cases the choked disc is likely to become rapidly bilateral. However, it is not always found even if pressure is exerted directly upon the straight sinus.

In unilateral sinus compression, the choked disc as a rule remains limited to one side, so, for instance, in case of compression of the cavernous sinus and the veins which empty into it, such as may be

induced by tumor formations in one frontal lobe. In addition to the changes in the papillæ there then occur, in case of strong and rapidly occurring venous stasis, extravasations of blood in the retina.

While in tumors of the posterior fossa and of the frontal lobes choked disc is a frequently observed and also an early manifestation, tumors of the cerebrum and particularly of the motor region in a considerable number of cases show no characteristic changes in the fundus, or if at all, only when the tumor has reached a considerable size. In tumors of the pons and the corpora quadrigemina, choked disc is likely to be absent.

In eighty per cent. of the neoplasms in which choked disc was not present at the beginning of observation it first developed, according to Cushing, upon the affected side. It is worthy of note that neuritic changes in the papillæ may occur also in conditions of softening of the brain substance.

A very important symptom of increasing intracranial tension consists in *slowing of the pulse.* We have observed the pulse to become as infrequent as thirty-six to the minute; the volume, however, remains full as a rule, and the tension strong. In slowly growing tumors, the slowing of the pulse is practically always absent.

General cerebral compression may cause death as the result of *paralysis of the center of respiration,* even before the slightest focal symptoms have developed, to make the diagnosis possible. Such fatalities are not infrequently observed; patients who enter the hospital in fairly good condition, have gone to pieces in short order with the symptoms of acute cerebral compression. In these cases we usually have to do with an acutely developed edema of the brain.

LOCALIZATION

From the general manifestations described we might well infer the presence of a brain tumor, but as to its location we can only make a definite statement if a certain circumscribed area of the skull invariably is painful on percussion, pressure or vibration. Cracked-pot resonance, which is obtained by percussion over the tumor region, the value of which has been particularly praised by Bruns, is only exceptionally to be elicited definitely enough to be of value for diagnostic purposes. Likewise dullness on percussion, and diminished resonance or tympany with or without the cracked-pot phenomenon, are only exceptionally found.

With these later signs, we now come to a consideration of focal

manifestations which point directly to the site of the lesion. But just as no sharp line of demarcation can be drawn between individual regions of the brain, and as, moreover, tumors do not limit themselves to the regional boundaries, similarly focal symptoms cannot be sharply differentiated. If for instance the posterior section of the frontal convolution is affected by a neoplasm, the central region will partake in the symptomatology of the case. Moreover, single symptoms such as hemianopsia may be aroused by the stretching of certain nerve tracks by disease processes in regions of the brain which lie a considerable distance apart. And it should be emphatically stated that a single local manifestation ordinarily is of little significance, and that a combination of all the symptoms and a proper weighing of the value of each alone offers safe ground for arriving at the focal diagnosis.

Just as the manifestations of the general cerebral compression are not constant, but are likely to undergo considerable changes in their severity, in the same way the focal symptoms at times only occur in attacks, or they show periodic exacerbations and remissions. This variation of symptoms affects all the focal symptoms described: and alternating symptoms, such as hemiparesis, are also observed.

In many regions of the brain we are as yet unable to recognize any characteristic focal symptoms. If tumors develop in these localities, there appear only the general symptoms of cerebral compression. Such areas of the brain are called *mute areas.* These comprise the anterior sections of the two frontal lobes, the posterior section also of the right, and the larger portion of the right temporal and parietal lobes, if we are dealing with the ordinary right-handed individual. In the right-handed person, the speech center is situated on the left, while in the left-handed, the number of whom is considerable, it is situated on the right. Disturbances of writing and reading are induced exclusively in right-handed persons by tumors in the left hemisphere; in most cases this involves the angular gyrus. The left hemisphere in right-handed persons also plays the most important rôle in the symptom of praxia, and in the recollection of form and color, as well as for the higher associative connections of simple memories and their spontaneous incitation.

While as a rule the focal symptoms which occupy the center of the clinical picture correspond to the chief location of the neoplasm, such a tumor in its growth exercises an ever-increasing influence upon the surrounding portions of the brain and the neighboring

nerve tracks. In addition to the direct pressure exercised by the tumor itself, the edema, the softening and the hemorrhage which occur in its vicinity, play an important rôle. The manifestations which result are generally designated as *neighborhood symptoms,*

FIG. 518

The external and superior aspects of the brain *in situ.*

and they may be of extreme importance as regards the mute areas of the brain. The manifestations which occur in regions of the brain and nerves at a considerable distance from the site of the tumor, such as symptoms referable to the frontal brain and the olfac-

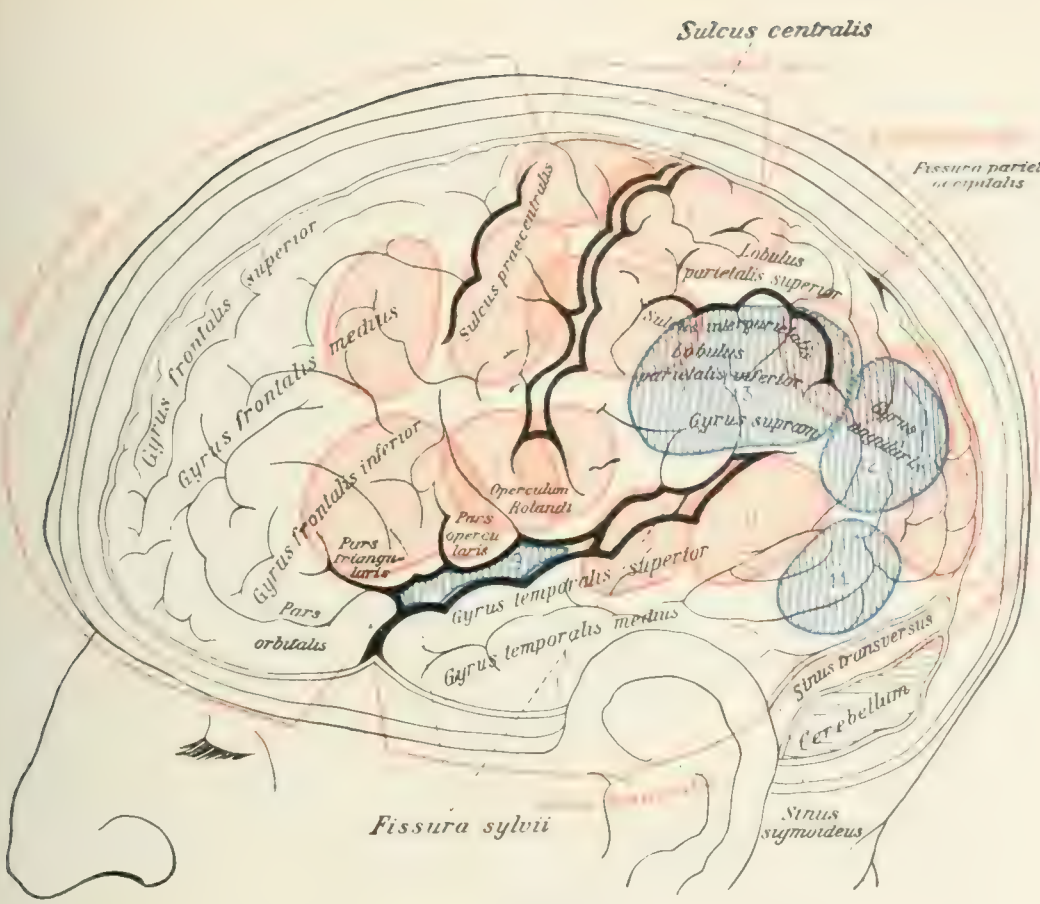


FIG. 519

Outline drawing of Fig. 518, to show the various centers; those in red are in the cortex, those in blue are subcortical.

1. Rotation of the head to the opposite side.
2. Motor aphasia. As the inferior frontal gyrus is drawn unforeshortened, the frontal speech area is represented relatively large.
3. Paralysis of the tongue, facial, masticatory, pharyngeal and laryngeal muscles of the opposite side (with the exception of the tongue, mostly transitory).
4. Paralysis of arm and hand; in slight injuries only paresis and apraxia.
5. Paralysis of leg and foot.
6. Disturbances of sensibility in the face.
7. Disturbances of sensibility in the arm; loss of sense of touch.
8. Disturbances of sensibility in the leg.
9. Insular aphasia; as the Island of Reil lies in the depths of the fissure of Sylvius, this focus can be represented only in its antero-posterior extent.
10. This focus lies in the superior and transverse temporal gyrus (of Heschl). As this gyrus is situated on the superior surface of the temporal lobe, and, like the insular gyri, behind this in the depths of the fissure of Sylvius, it can only be suggested in this sketch. In bilateral destruction of 10, an apparently complete cortical deafness occurs, for, according to Flechsig, the centre for audition is situated in Heschl's gyrus. It is said that in left-sided destruction of this area pure word deafness alone occurs.
11. Sensory aphasia.
12. Near the surface, alexia and agraphia; in the depths, near the medial surface, pure alexia.
13. Near the surface, slight disturbances in reading and writing: amnetic aphasia; deeper, apraxia.
14. Amnetic aphasia and optic-tactile aphasia.
15. In bilateral destruction: mind blindness, which, however, may arise through combined injury of other foci; also amnetic (particularly optic) aphasia, the latter also in lesions limited to the left side. The occipital brain is shown much foreshortened in the drawing.
16. Conjugate deviation.

tory nerve which are aroused by tumors in the occipital lobe, are designated as *distant symptoms.*

As the result of the destruction of definite circumscribed sections of the cerebrum, cortex or medulla, characteristic manifestations are produced which as true focal symptoms are of definite importance for the localization of the site of the tumor. In the central region they coincide so well with the results obtained by Faradic stimulation (see Plate 83), that in this region both methods may be combined in investigating the function.

In Figs. 518, 519, 520 are shown the localization of the functions so far as we have yet been able to determine them from the clinical manifestations. These determinations, of course, are therefore only approximate. In the sketches we have depended in a large measure upon Figs. 161 and 162 by Hugo Liepmann, in Hans Curschmann's Lehrbuch der Nervenkrankheiten, Berlin, 1900.

THE EMPLOYMENT OF SUCTION IN THE REMOVAL OF BRAIN TUMORS

In a series of cases we have made use of suction for the purpose of seizing and drawing out the tumor. Of the localizable brain tumors, only those which are encapsulated may be extirpated with certainty. In the diffuse glioma the boundary where the diseased tissue ends and normal tissue begins cannot be recognized even at autopsy; in the microscopical examination itself, the pathologist finds it difficult or impossible to determine the boundary line. At the time of operation we are much more dependent upon contingencies.

But the extirpation of encapsulated tumors also causes difficulties when we have to shell them out from the brain substance. Even with the greatest care it is frequently impossible to accomplish the desired result by means of a scoop or other rigid instrument. The difference in consistencies is so slight that one strikes either into the brain or into the tumor, and in the latter case, portions of the tumor remain behind.

Up to the present time we have enucleated tumors in the ordinary way, by means of the fingers, a technique which we still frequently use. By this method, there can be no doubt but that a large number of nerve fibers are destroyed unnecessarily. This may still be tolerated in the cerebrum, where the manifestations of disturbances of function following operation are not so severe, if no important

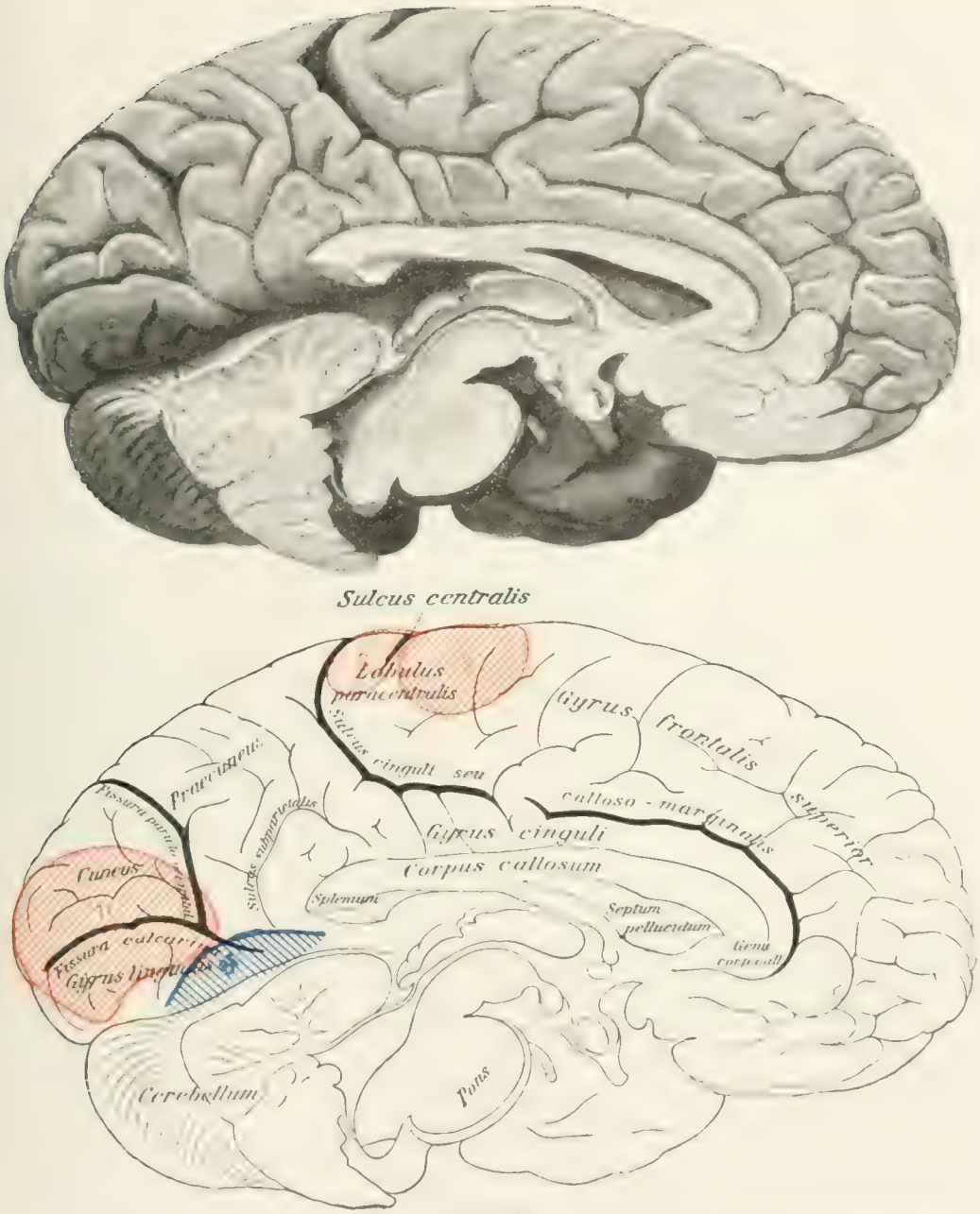


FIG. 520

Left hemisphere, showing the mesial surface. (The brain has been removed from the skull, and on account of its soft consistency has flattened down somewhat.)

5. Cortical focus for paralysis of the leg.
7. Cortical focus for sensory disturbances in the leg.
17. Cortical focus for right hemianopsia.
18. Subcortical focus for amnestic aphasia.

centers are involved. But in the cerebellum, and particularly in the neighborhood of the medulla oblongata, such enucleation with the fingers may, under certain circumstances, cause immediate death. The tumor may have been readily enucleated with the fingers, and the patient may have left the table in a fair condition, but after five or six hours, as we have frequently observed, the respiration begins to fail and the patient dies with all the signs of respiratory paralysis, while the heart continues to beat strongly and regularly. This condition results from disturbances on the floor of the fourth ventricle, which in a large part have been induced by the operation.

Now it would be considerably better if we could draw out such a tumor with some sort of instrument, and enucleate it. But on account of the consistency of the tumor, this cannot be done. Usually the neoplasms are soft or semisolid, and they tear upon seizing them with a volsellum or a Muzeux forceps.

For that reason since 1908 we have on occasion employed an apparatus for applying suction to the exposed tumor. We learned from Dr. Schuster a fact that has been of great value to us, that physiologists have been extirpating tiny portions of the cortex and of the subcortical region by puncturing it with a pointed glass cannula, and applying suction. A water-jet pump supplied the strong suction necessary for the purpose. Our aim has been not to suck out the tumor, but solely by means of the vacuum to get a firm hold upon it for further manipulation. This type of pump was first introduced into surgery by Perthes, who recommended it many years ago in the after-treatment of operated cases of empyema.

We have employed attachments of glass, since the effect of the suction can be closely observed through them. Glass cylinders of various diameters (10 to 60 mm.) are used, which are rounded off in front in order that they may set well, and behind they go off at right angles into a tube for the attachment of the rubber connection (Fig. 523). In order to assure asepsis, the cylinder is first connected up with a rubber tube 40 cm. long, which can be boiled. This is later connected with the tubing from the pump by means of a glass cannula.

After the surface of the tumor is exposed so far as possible, the largest suction glass which fits is applied over the surface of the tumor and suction is begun. The suction is made strong enough so that the glass cylinder and the tumor represent from now on a single unit. It is possible that with a tumor of firm consistency

and with a nodular surface the suction tube will not take hold. Then it is necessary only to shove on to the front of the suction glass a few millimeters of very soft rubber tubing of the proper size.

To prevent the suction from becoming too strong, especially in the posterior fossa where it is possible to suck the medulla itself into the glass, the apparatus can be so arranged that the negative pressure may be interrupted immediately when desired. For this purpose we have had a small hole drilled in the cylinder which is kept closed with the finger tip. By removing the finger from the hole, the suction is immediately broken.

To avoid misunderstanding, it should be said once more that we employ suction not for the purpose of sucking out the tumor, but for fixing it by its surface in such a manner that the suction bell gives us a hold by which to manipulate it as desired. The majority of tumors are of so firm a consistency that suction thus applied does not tear them; they may ordinarily be seized *in toto* by the suction apparatus. Pure sarcoma is at times so friable that we have seen a sarcoma of the hypophysis fall to pieces when suction was applied, so that it had to be removed with a scoop.

To show how this technique is carried out, we will present later a case of tumor of the frontal lobe.

NEOPLASMS OF THE FRONTAL PORTION OF THE BRAIN

The frontal lobes comprise the cerebral convolutions which lie in front of the precentral sulcus (Fig. 519, p. 529). Of these there are three, designated as the superior frontal gyrus, the middle frontal gyrus, and the inferior frontal gyrus. The base of the frontal lobes rests upon the orbital roof and extends backward as far as the border of the lesser wing of the sphenoid; that is to say, they occupy the anterior fossa of the skull. As a result of their anatomical location, the frontal lobes are readily accessible.

PSYCHIC DISTURBANCES

In case of tumor of the frontal brain, peculiar psychic disturbances are sometimes observed which have been given the term *moria* (childish dementia) by Jastrowitz, and have been described under the name of *Witzelsucht* (referring to the tendency to play clownish tricks) by Oppenheim. The patients cut up pranks which are carried out in a jolly mood, and they make foolish and childish

remarks. There may be present at the same time, as the result of the cerebral compression, some torpor or stupefaction, or this may alternate with periods of excitation. In addition, there is to be observed a decrease in the intelligence, and particularly also a loss of memory. This symptom may, however, although less frequently, occur in tumors in other regions of the brain, even in the posterior fossa, which naturally limits its diagnostic value.

CEREBRAL OR FRONTAL ATAXIA WITH TUMORS

In tumors of the two superior frontal gyri there frequently occur disturbances of equilibration in standing and walking, that is to say the patients present a picture of cerebral ataxia (frontal ataxia of Bruns), which reminds us sharply of the swaying gait and the uncertain poise characteristic of foci in the posterior fossa (cerebellar ataxia). In the absence of neighborhood symptoms and of local bone manifestations, diagnosis of tumor of the cerebellum is all the more possible, as choked disc and the general symptoms of cerebral compression occur in frontal tumors just as in tumors in the posterior fossa.

ROTATION OF THE HEAD AND EYES

It has been found that the centers for rotation of the head and for the movements of the eyes are located in the middle frontal gyrus. If the cortical visual center (motor) in the frontal brain is paralyzed, the patient loses the power of looking to the opposite side, and therefore turns both eyes toward the side upon which the lesion occurs. The cause of this *conjugate deviation* has not been clearly explained. In man we have observed that on stimulation of the base of the middle frontal gyrus the head is twisted with great force toward the opposite side.

In neoplasms of the frontal brain, stiff neck has also been observed as the result of tonic contraction of the muscles of the neck, of the cervical spine, and of the trunk, in the latter case associated with opisthotonos. These manifestations also present a similarity to those observed in cases of tumor in the posterior fossa.

NEIGHBORHOOD SYMPTOMS

As result of the pressure of the tumor, the conductivity of the olfactory tract and bulb on the same side may be interfered with

secondarily; the nearer the location of the tumor to the base of the frontal brain, the more likely is this to occur. Tests of the sense of smell should never be omitted. Unilateral disturbances of smell are, in any case, of greater significance than bilateral. Anosmia (total loss of the sense of smell) is a finding which is difficult to value properly, and there is no way of knowing definitely just how keen a sense of smell the patient previously possessed.

Not only the olfactory lobe, but the optic nerve also, may be indirectly involved. In such cases in frontal tumors choked disc is likely to appear early and is very likely to show first upon the side of the tumor. A unilateral blindness is sometimes observed as the result of atrophy. Pressure on the chiasm or the optic track may give rise also to various forms of hemianopsia. Only in large tumors does exophthalmos occur, and involvement of the nerves which enter the orbit (the oculo-motor, trochlear, first division of the trigeminus, and the abducens). These symptoms are much more frequently observed in case the tumor takes its origin from the base of the skull.

The center of Broca lies on the left side at the foot of the inferior frontal gyrus. Tumors which involve this immediate vicinity, or which develop in its neighborhood, lead accordingly to motor aphasia, and occasionally also to agraphia. On the right side where the motor center of speech is not located in right-handed persons, one may extirpate extensively, more so than in any other portion of the brain.

Summing up all of which we have certain knowledge as regards local manifestations in tumors of the frontal region, the result is rather paltry, and we are justified in calling the anterior section of the frontal brain particularly a mute region. The right side offers still less favorable conditions for diagnosis, for in right-handed persons the speech center is also lacking or is at least undeveloped. The clinical manifestations are more abundant if the tumor presses into the neighborhood of the precentral gyrus. Then, according as the location of the tumor is in the superior, middle, or inferior frontal gyrus, the centers of the leg, the arm, or of the facial and hypoglossal nerves are sooner or later involved. On stimulating the precentral gyrus, clonic contraction occurs on the opposite side of the body which show the characteristics of Jacksonian attacks; later paralysis may occur as the result of pressure. Such manifestations are neighborhood symptoms.

EXPOSURE OF THE ANTERIOR POLE OF THE FRONTAL BRAIN

For exposure of the anterior pole of a frontal lobe, a trap-door corresponding in size and position to the anterior flap in Fig. 521 suffices. The base of the flap is best directed backward toward the temporal muscle. Occasionally, for instance in abscess, the frontal sinus and the orbit must be opened up at the same time. In such a case, it is of advantage to have the base directed backward, so that if necessary the Krönlein operation (see Vol. I, p. 160) may be carried out immediately following.

EXTIRPATION OF A LARGE FRONTAL TUMOR

A civil official, thirty-four years old, was taken sick in July, 1908, with chills, headache, roaring in the ears and vertigo, which was so severe that he collapsed. Beginning in October, vomiting without nausea had frequently occurred in the morning. In November vision became impaired, and the patient saw double.

The condition when we saw him in February 1, 1909, was as follows: The sense of smell was entirely lost on the left side. On both sides there was choked disc, more advanced on the left than on the right. The patient perceived light on the left side exclusively in the temporal visual field, that is to say, he had nasal hemianopsia. On the right, he could count fingers at a distance of six or eight feet. Reading was practically impossible. No hemianopsia could be demonstrated in the right eye. The corneal reflexes were active on both sides, and slight paresthesiæ were present in the region of the left cheek and forehead. The left corner of the mouth drooped, although the innervation was equal on both sides. Paresthesiæ occurred in the left finger tips, and sometimes also in the right. There was no ataxia, but the fingers showed a tremor on movement. All tendon, skin, and periosteal reflexes were active, and showed no abnormality. The vertigo sometimes suddenly disappeared; he could not stand on the left leg alone, and on walking with the eyes closed, he bore off to the left. Otherwise there was no other sign of trouble with the nervous system. We made the probable diagnosis of tumor in the left frontal lobe.

Operation was performed in two stages on the 9th and 29th of February, 1909. On account of the large exposure required, a double trap-door was formed opening front and back (Fig. 521, Plate 89). The hemostatic suture included the entire left anterior quadrant of the skull. It began over the nose, was carried along

the left eyebrow, and upward in front of the ear; a second suture ran from the same point up along the middle line to meet the first one at the anterior fontanelle. The skin incision was laid out beforehand by scratching the skin with a knife.

The first incision made was a vertical one in the middle between the two flaps. One drill hole was made at the lower end and another at the upper end of the incision, and after carefully lifting away the underlying dura, the two holes were connected with the Dahlgren forceps. Then the anterior flap was completed, with its base corresponding to the middle line. On account of the convexity of the skull at this point, after the transverse skin incisions were completed, one above and one below, a drill hole had to be made at their anterior ends. Then the two drill holes above and the two drill holes below were connected by the Dahlgren forceps.

The convex bony flap could, however, be broken across and turned forward only after the resistant bone in this region was chiseled across at the base of the flap for a short distance from each drill hole with the Doyen chisel. In the anterior lower corner of the wound the frontal sinus was exposed. The anterior wound surface bled from the torn mucous membrane of the frontal sinus, numerous small emissaries, the longitudinal sinus, and some of the Pacchionian granulations, so that a strip of gauze had to be packed in and left in place. The end was brought out through the upper anterior corner of the wound.

In a similar manner the posterior flap was formed. This was broken backward readily as the bone becomes much thinner as one proceeds posteriorly. In the process the anterior branch of the middle meningeal artery, which ran up from the base of the opening, was torn. The bleeding lumen was seized with a hemostat and tied off. Here also at both angles of the base of the flap a small strip of gauze had to be introduced on account of the continuous ooze of blood. The entire osteoplastic opening was 8 cm. high, 11 cm. long above, and 10½ below.

The exposed dural surface extended from the longitudinal sinus in front over the frontal lobe as far back as the fissure of Sylvius, which could be recognized externally by a depression about 1 cm. wide in the vaulted surface of the dura. The tension of the dura was considerable, for in spite of the extent of the exposed surface, it showed no pulsation. Pulsation could not be felt even on palpation. At the anteror pole and somewhat toward the base, there was

a yellowish-red discoloration on the dura with a peculiar irradiation of blue vessels which gradually shaded off into the surroundings. The size of this suspicious area was somewhat larger than a half dollar. At a short distance away, the dura showed its normal bluish-white shade. At the end of the operation the two flaps were replaced and sewed in, the three strips were brought out through the anterior upper and the posterior upper and lower angles and the hemostatic suture was removed.

The patient stood the operation well and on the following day had no complaints. The pulse rose to 120 and the temperature to 100.8. The eyelids and skin of the cheek were edematous and ecchymotic on the left side. The patient vomited twice. On the third day some of the stitches were removed, together with the packing, except for that in the frontal sinus. On the sixth day the evening temperature was 100, and the pulse was down to 100. Contractions occurred several times in the right hand, and hiccoughs, together with headache, restlessness, and weakness. On the seventh day the hiccough disappeared and the headache was somewhat less severe. Otherwise gross examination showed no change in the condition. On the ninth day the packing was removed from the frontal sinus; the temperature had come down to 92.2, and the pulse continued at 100 or a little over.

At the second stage of the operation, performed February 20th, the incisions, which were rather firmly united, were opened up with scissors and the flaps turned forward and back (Fig. 521, Plate 89). The dura protruded into the anterior portion of the opening like a hemisphere; pulsation was now visible. The dura was first incised at the upper margin of the opening parallel to the edge of the bone, and on account of the large extent of the opening, two dural flaps were formed, one in front with its base downward, and the other behind with its base backward (Fig. 522, Plate 89). A single dural flap, with its base below, could not have been turned down satisfactorily on account of the necessary width and of its convexity.

The tumor could now be seen in the frontal pole immediately beneath the cortex. A large pial vein crossed it in the direction of the longitudinal sinus; a ligature was passed around this on a needle, and it was double-tied and divided. The neoplasm could be differentiated by means of its rather firm consistency when compared with the normal brain substance.

Extirpation of a tumor of the frontal region. Plate A.

Fig. 521. Double trap door, necessitated by the large area to be exposed (first stage of operation).

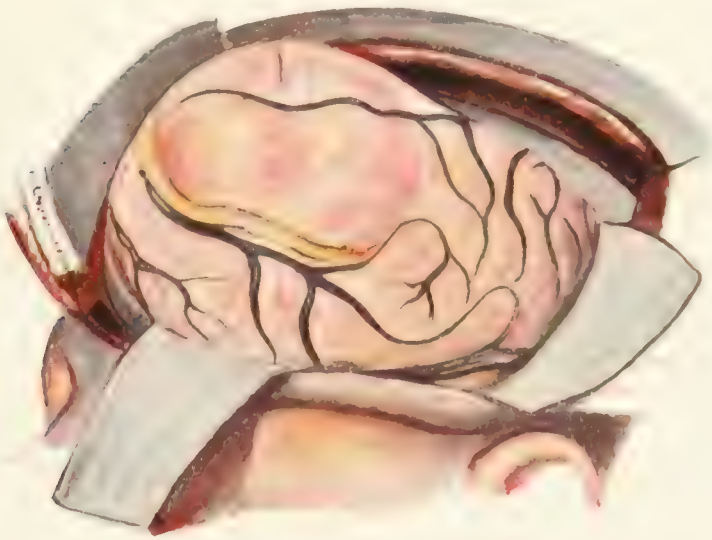


Fig. 522. Formation of two skin flaps (outlined and packed)

Extirpation of a tumor of the frontal region by suction, Plate B.

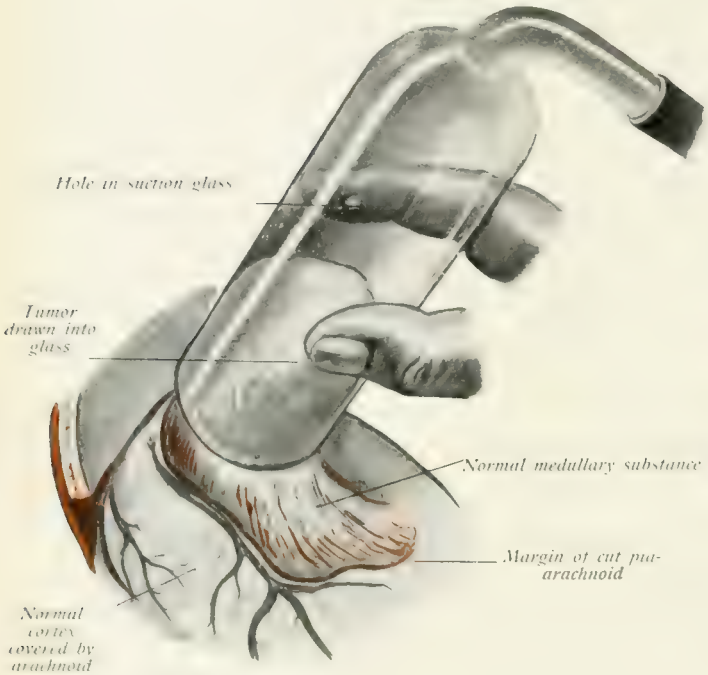

Hole in suction glass
Tumor drawn into glass
Normal medullary substance
Margin of cut pia-arachnoid
Normal cortex covered by arachnoid

Fig. 523. Suction is applied to the tumor.

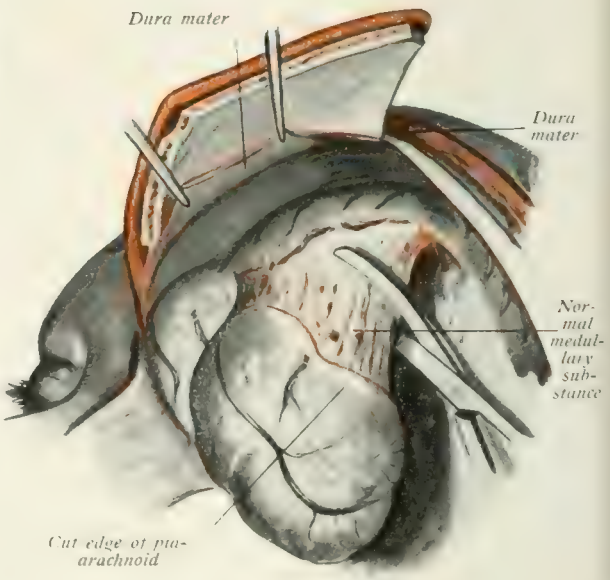


Fig. 524. Division of the medulla forming the pedicle of the tumor.

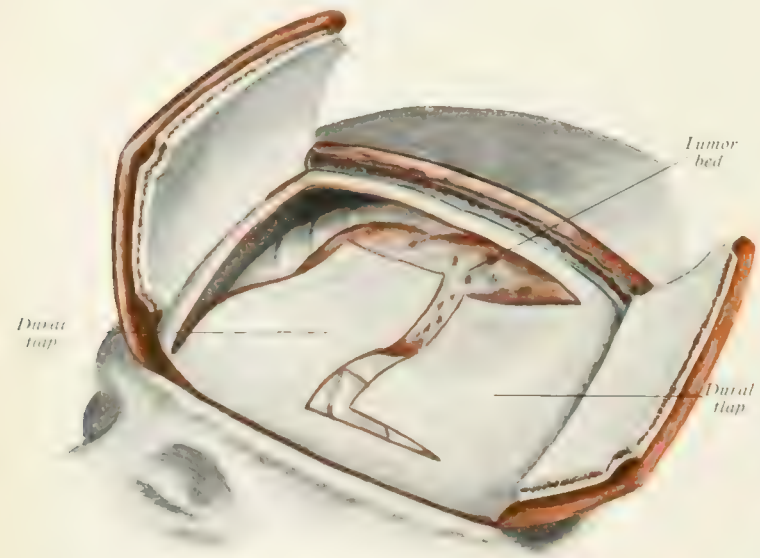


Fig. 525. The two dural flaps are turned in on the bed of the tumor.

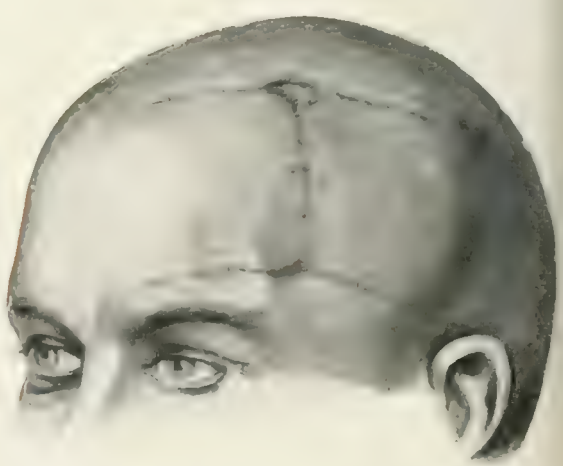


Fig. 526. Condition three weeks after extirpation of the brain tumor.

At its lower margin the pia was torn with two forceps at a point corresponding to the tied-off vessel; then with gauze sponges and the finger, we proceeded carefully between the tumor and the brain substance. Then the pia was incised at the posterior margin of the tumor with scissors and the same procedure was carried out here. After tying off a large pial vein, the pia was then incised at the upper margin. In front toward the longitudinal sinus several veins were injured in the process of freeing up the tumor, causing severe hemorrhage which necessitated packing.

Now the tumor, which seemed to be a diffuse glioma, was freed up from its bed round about by means of finger and gauze. But since it had no capsule, dependence had to be placed upon the feel of the tumor, care being taken to include all the firm tissue. In order to avoid too severe a mechanical injury of the surrounding brain in this procedure, a large suction glass, of a diameter of 40 mm., was placed over it (Fig. 523, Plate 90). The effect was so strong that the larger portion of the tumor was immediately sucked up into the cup. Thus the tumor was seized by the suction apparatus, and while it was held fixed with one hand, the other hand with a gauze sponge carefully pressed back the normal brain substance. In this way as little of the normal brain substance was injured or removed as possible. When the tumor was completely enucleated and lay displaced upon the surface of the brain, it hung by a broad pedicle of medullary substance corresponding to the tissue with which it was surrounded within the brain, and this was divided with scissors (Fig. 524, Plate 90).

In the manipulation the entire left frontal pole of the brain was removed; the tumor measured in length 9 cm., in width 6, in thickness 3. The falx cerebri and the longitudinal sinus lay exposed for a considerable extent. As the result of the extirpation, a large flap of brain substance was formed toward the central region; this was laid from below and behind over the defect in the brain, and was held in place by turning back the dural flaps (Fig. 525, Plate 90). The dura was not sewed, as on account of the infiltrative nature of the tumor one could not be sure that the affected tissue had been entirely removed. Leaving the dural incision open formed the best method of insuring the patient against the return of pressure symptoms in case of recurrence. The skin wound was united without drainage or packing, as there was no hemorrhage. A dry sterile dressing was applied.

On the evening following the operation the patient was somewhat confused, but he answered very distinctly when spoken to. There was no paralysis. The dressing was saturated with cerebro-spinal fluid, and was accordingly reinforced by applications of iodoform gauze; this latter was renewed daily, while the original dressing was not disturbed. On the next morning, although consciousness was retained, an aphasia developed which was complete except for the occasional utterance of his own name. This began to disappear in two days, and two days later had disappeared entirely, except for the lack of a few words.

Otherwise the course of the convalescence was, for so severe an operation, surprisingly good. The temperature never rose above 99.5, the pulse never above 100. No paralysis appeared in the extremities; the appetite was good after the third day, the patient slept without opiates and he felt well, and his mind was clear after the fourth day. The flow of fluid on the fifth day after operation when the dressing was first changed was still slight, and on the twelfth day there was none. On this day the dressing was changed for the second time, and all the stitches removed. A protective dressing covered the large wound, which had healed by first intention. In less than three weeks (March 11th) the patient was discharged. Fig. 526 shows the condition of the wound at this time.

Shelling out such a tumor with the finger would very likely have been followed by severe disturbances. It would have caused the destruction of considerable portions of the brain substance, and might have led to a secondary softening over an extended area, which would have given considerable trouble for several weeks, if it were not fatal.

A letter received about the middle of April stated that the patient was once more in good health. The vision of the left eye had returned to a large extent, but that of the right eye had diminished considerably. Microscopic examination confirmed the diagnosis of diffuse glioma. In the middle of May disturbances again made their appearance, first aphasia and then right-sided spasms followed by paralysis. On May 25, 1909, the patient died in the hospital at Chemnitz with symptoms of increasing paralysis.

NEOPLASMS IN THE CENTRAL REGION

The anterior and posterior central convolutions bound the fissure of Rolando (the central sulcus) in front and behind. This may

best be located on the skull by means of the formula of Krönlein, although it must be stated most emphatically that not one of the methods of the cranio-cerebral localization at present in use can be entirely relied upon. In skulls which are unusually long, as well as in short and dome-shaped crania, the relations are distorted. One should always be prepared for this, and make the opening sufficiently large to allow for any discrepancies.

As is shown on Plate 83, the foci for the lower extremity lie near the median longitudinal fissure of the brain. The centers for the facial and hypoglossal nerves, and so on, are found on or within the operculum of Rolando, that is to say, in the immediate neighborhood of the fissure of Sylvius (lateral cerebral fissure). Between the two are arranged the centers for the upper extremities, which are to be sought rather far up. In this very point mistakes not infrequently occur, as we have learned through cases which we have had to re-operate, after having been previously operated on by others.

SIGNS OF MOTOR IRRITATION AND PARALYSIS

Since the cortical motor area occupies the wide extent from the region of the longitudinal sinus down to the fissure of Sylvius, a tumor, certainly in the beginning, and sometimes even after it has developed to a considerable size, directly involves only a limited number of centers. This means that every motor disturbance which takes its origin in the cortex is limited in its manifestations at first to one extremity or to one section of a limb.

The first effects of a tumor are likely to be symptoms of irritation, expressed in the form of spasms definitely limited to a smaller or larger section of a limb. Gradually neighboring centers are affected, so that the contractions extend in a regular manner and may run a course corresponding to the characteristic picture of a Jacksonian or cortical epilepsy (see p. 503). The physiological arrangement of the centers to which the progression of the focal symptoms correspond is of great importance from the point of view of diagnosis, particularly when other signs of tumor formation (headache, vomiting, stupidity, vertigo, slowing of the pulse, choked disc) are lacking.

Ordinarily, in tumors of the central convolutions the initial convulsions are followed by paralysis, which at first are of a transitory nature. As the tumor of the cortex increases in size, it destroys

the cortex together with the subcortical nerve apparatus. This explains the permanent paralysis, which characteristically, corresponding to the scheme outlined above, ordinarily first occurs as a monoplegia (facial, facio-lingual, facio-brachial, brachial, crural). As a persisting paralysis always shows that certain definite areas of the cortex have been destroyed, it is of greater diagnostic value than are monospasms; the latter may appear as the result of the influence of the tumor upon the neighboring regions. Paralyses which arise from the cortex are of a spastic nature.

SENSORY IRRITATION PHENOMENA AND PARALYSES

The sense of position, the sensation of movement, and the senses of locality and of space are localized for the most part in the posterior central convolution. They are arranged for the face and extremities in the same order as the centers in the anterior central convolution. The sensations of touch and of pain both extend from the posterior central convolution into the anterior section of the parietal lobe (see Fig. 519, p. 529).

In tumors in the middle third of the posterior central convolution and in the immediately contiguous portions of the lower parietal lobe (see Fig. 519, No. 7 red), tactile agnosia (loss of the sense of touch) is observed. This symptom is explained by a loss of the conception of touch which, from the contents of the brain sensations, constructs the representation of objects. If the recognition of form is lost, this condition is called astereognosis. To test the stereognosis, which may also be disturbed by peripheral nerve paralysis, conductivity and motility must be preserved in sufficient extent in order to allow of active palpation by the patient.

Tumors which originate in the posterior central convolution at first usually produce disturbances of sensation; the motor manifestations appear later through participation of the anterior central convolution. At the time of operation the locality of the anterior convolution can be determined only by the results of Faradic stimulation; if this fails us, as so commonly happens in tumor formations, we are left entirely at sea.

At other times, sensory paralysis, although slight in extent, is associated with the motor paresis and paralysis of the extremities, and ordinarily the deep sensibility is more apt to be affected than superficial or skin sensation. Disturbances of the sense of position and of stereognosis, as well as ataxic manifestations, then appear.

A marked involvement of the sensibility justifies the conclusion that the posterior convolution or the subcortical fibers which lead to it are affected by the new growth, while if the growth is located only in the anterior convolution, the deep sensibility alone seems to be affected.

Apractic disturbances occur in their purest form in new growths of the left parietal lobe. However, they may be aroused by tumors of the central convolution and of the semi-oval center, particularly if it has not led to a complete paralysis of the right upper extremity. Then the left hand frequently shows dispraxia.

SUBCORTICAL TUMORS

In subcortical glioma, the convolution overlying it is often seen to be of a peculiar yellow color, which sometimes spreads out over a considerable area. In a rare case of metastatic hypernephroma observed subcortically in the motor region, the entire area gave the impression of fluctuation.

While Jacksonian attacks are the rule in neoplasms of the cortex of the central region, they are less frequently observed in tumors developing subcortically, and they are frequently entirely absent, particularly in cases of glioma. The paralysis, as a rule, is of the flaccid type. The irritation of the tracks in subcortical tumors does not express itself in the form of a clonic spasm, but ordinarily in tonic contractions of the affected muscle groups. Nevertheless, in tumors which are situated exclusively in the subcortical region, typical manifestations of motor and sensory irritation may occur.

NEIGHBORHOOD SYMPTOMS

The pressure exercised by a growing tumor, the edema in the surrounding tissue, which varies from time to time, and finally hemorrhage into the adjoining brain substance, combine to produce effects which are of great diagnostic importance. Thus tumors which encroach only to within a certain distance of the inner capsule may cause symptoms of the same nature as if they had pressed upon and destroyed a section of it. Tumors of the motor region and of the parietal lobe lead in this manner also to crossed hemianopsia; this symptom is accordingly not always to be referred to involvement of the visual center situated in the occipital lobe, or to a break in the paths of conduction in the optic tract.

The neighborhood symptoms are observed not only in the depths,

but also upon the cortical surface. In such manner tumors of the senso-motor region involve the center of Broca at the foot of the anterior frontal gyrus (see Fig. 519, No. 2), and the Wernicke center in the upper temporal convolution (Fig. 519, No. 11), and thus not infrequently result in disturbances of speech of both a motor and sensory nature.

Finally, it must be emphasized that from the surgical point of view the differentiation between tumors of the anterior and posterior convolution is not of extreme importance. For these reasons we must in all operations expose an area of considerable size, which includes at least the entire width of the senso-motor region.

EXPOSURE OF THE CENTRAL REGION

No special instructions are necessary in regard to exposure of the central region, as a number of cases describing the procedures in this region have already been given in the chapter on Operative Treatment of Epilepsy. The technique of the extirpation of a tumor in this locality is described in the following case.

A forty-one-year-old manufacturer received a bullet wound at the age of fifteen years; the bullet proceeded through the upper regions of the abdomen into the left pleural cavity and caused an empyema which healed after a rib resection. The bullet remained in the body without causing symptoms, so that the injured man was able to serve in the artillery, and for over fifteen years took part in the military maneuvers without difficulty.

At the age of thirty-nine (June 22, 1908) he was suddenly seized one morning, while asleep in bed, with an attack which consisted in tracheal râles and convulsive contractions. The tongue was bitten so that it bled. On awakening the patient experienced a very distressing sense of suffocation, and he could not move or talk, although he heard everything, and was aware of all the details of the medical examination. Half an hour later he was physically and mentally normal. Fifteen months before this attack the patient had fallen, striking his right temple heavily against the corner of a wall; he had had to sit down, but was not rendered unconscious.

Four weeks after this attack a second one appeared, also during sleep. From time to time the attacks recurred. The diagnosis of epilepsy was made, and the bullet was considered the cause. It was located by the Roentgenograph two months later (September 30, 1909), and was removed after a resection. It was found em-

Enucleation of a tumor of the central region.

Fig. 527. Exposure of the dura mater (first stage).

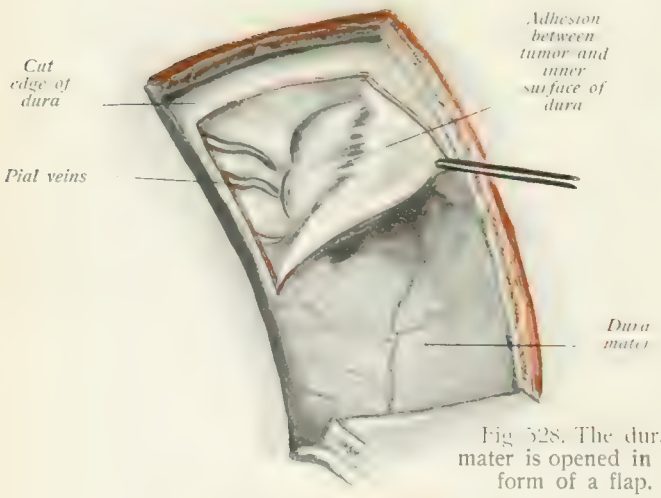


Fig. 528. The dura mater is opened in the form of a flap.

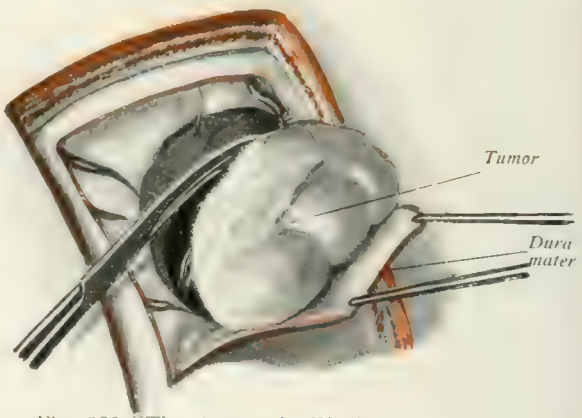


Fig. 529. The tumor is lifted out by traction on the dura mater.

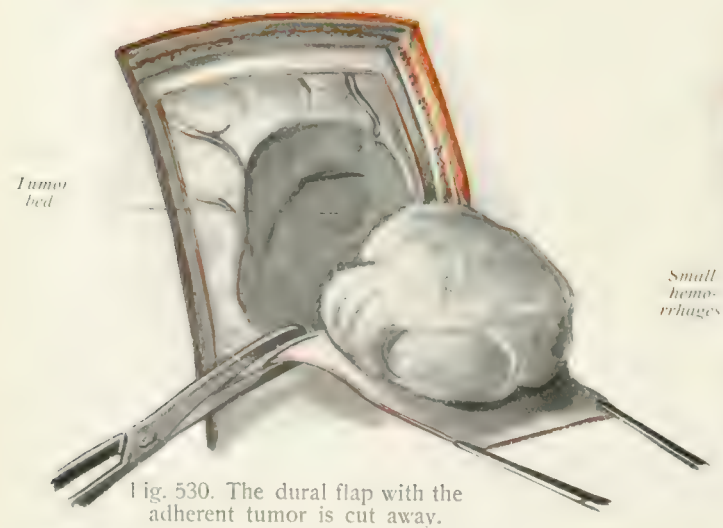


Fig. 530. The dural flap with the adherent tumor is cut away.

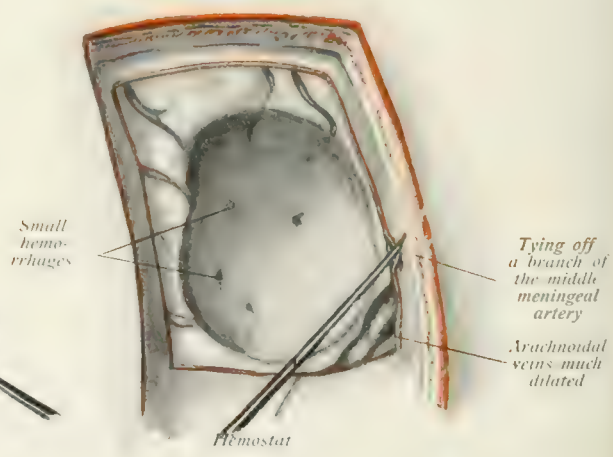


Fig. 531. Bed of tumor exposed.

bedded in scar tissue in the periosteum of the rib below the left axilla. In the interval the patient was treated with bromides and general therapy. Eight days after the operation another attack occurred. With a single exception on January 16, 1909, when an attack occurred with loss of consciousness and biting of the tongue, all the later attacks were of the following description.

They began with dryness in the mouth and an abnormal sensation (feeling of vibration, sleepiness, loss of sensibility or rigidity) in the left side of the mouth, the upper lip, ala of the nose and the tongue. Occasionally visible tremor occurred in the left half of the tongue and in the corner of the mouth; at the same time the patient could actively move the parts. Then a feeling occurred as if the fingers of the left hand were going to sleep: it began in the thumb, then it always followed after a few seconds in the index finger, the third, fourth, and fifth finger, then it involved the palm of the hand, travelled into the wrist joint or ran up into the forearm, involved the upper arm and ended in the lateral region of the neck.

The attacks occurred from one to three times a month, although occasionally several times on the same day, and they lasted from start to finish five to ten minutes. The course was so slow that the patient at the beginning could retire from the company or lie down in order to be prepared for a major attack which was about to occur, as he knew by previous experience. At times there was palpitation of the heart as well as pains in the left side of the breast. The last few months the prickling sensations involved also the left shoulder, the jaw-bone, scalp, and concha of the ear on the same side.

A slowly developing disease process in the lower section of the right central convolution was to be inferred. Whether it was a tumor or a tumorlike formation such as a cyst, or was only a chronic inflammatory condition resulting from the injury received in March, 1907, could not be determined. In an examination made in consultation with Oppenheim on January 18, 1910, there was found a slight left-sided paresis and a positive Babinski sign in the right foot; the abdominal reflex was absent on the right side.

Operation was undertaken in two stages, on the 20th and 31st of January, 1910. At the first stage after the hemostatic suture was applied a bony trap-door was made with its base below (Fig. 527, Plate 91). On making the bony incision in front there was

strong arterial hemorrhage. The meningeal branches in the dura were found to be unusually numerous, tortuous and large; they spurted at three points and had to be tied in the regular manner. In the center of the exposed dura somewhat anteriorly was found a depression, 33 mm. wide and 25 mm. high. In order to expose this completely, an additional strip of bone had to be removed in front, so that the entire osteoplastic opening finally reached the dimensions of 87 mm. wide by 96 mm. high.

On the 31st of January the trap-door was reopened by blunt dissection with scissors. The dura was covered with thin clots, which could readily be removed with the blunt curette. The dura was now opened with a knife at a distance of 1 cm. from the upper and posterior bony margins, and the rest of the incision was made with scissors (see Fig. 528, Plate 91). As the posterior upper corner of the dura was lifted up with two forceps, there appeared immediately a reddish-yellow tumor, which had grown to the inner surface of the dura over a considerable distance, and had evidently taken its origin from the dura or its arachnoidal lining. It was a case of capsulated fibro-sarcoma, the most favorable type of cerebral neoplasm which we meet.

The dural incision was then carried down along the anterior bony edge at a distance of a few millimeters. The upper margin of the dural flap was seized with two clamps and carefully lifted away, which resulted in the tumor freeing itself from its bed. In color and consistency, its smooth, slightly nodular surface could clearly be differentiated from the brain surface surrounding it. Accordingly, the brain substance could be cleared away from the tumor with closed scissors without difficulty, while the tumor was being carefully lifted with the dura to which it was united (Fig. 529, Plate 91).

In this process three isolated vessels going from the brain substance to the tumor were put under tension, and were tied with catgut near the brain and then divided peripherally. The ends of the vessels which were connected with the tumor spurted, showing that the tumor received a considerable portion of its blood supply through the base of the dural flap, which had as yet not been divided.

In this manner it was possible to develop the entire tumor so that it finally hung only by the base of the dural flap. The extirpation was completed by division of the dura along this line (Fig.

530, Plate 91). Several vessels which spurted freely had to be encircled with threaded catgut and tied off before the base was cut. This process was carried on in such fashion (Fig. 531, Plate 91) that the threaded needle was introduced from the outer surface of the dura close to the wound margin, carried about the spurting vessel on the medial side of the dura, and then again brought out and the catgut tied. This is the best way to prevent the ligature from slipping.

The bed of the tumor (Fig. 531) was a cavity the size of a plum and was carefully examined with the eye and finger for remnants of the tumor, for it is in just this form of tumor that small isolated processes may run off into the depths of the brain, as we have several times observed. As all wiping and sponging of the brain substance was to be avoided as far as possible, the blood clot was removed from the cavity with smooth forceps. The tumor measured about 60 mm. in length and width, in thickness it was about 45 mm.; it was attached to the inner surface of the dura over an area 30 to 35 mm. in extent.

The cavity was found to be clean, as might be inferred by the smooth, firm surface of the tumor. Hemorrhage in the tumor bed was satisfactorily controlled by two ligatures. The cavity in the brain did not immediately fill in; a depression remained which was the size of half a small apple; a dural plastic was not undertaken. The skin and bone flap was carefully sewn back into place without drainage or packing.

The course after operation was without incident. The temperature never rose beyond 99.8; the pulse rose on the first evening to 124, on the second to 96, and after that it never went beyond 80. There was no flow of cerebro-spinal fluid and the first dressing was not disturbed for ten days. The stitches were then removed, the flap having healed in by first intention. Three weeks after the operation the patient left the bed and five days later journeyed back to his home.

In addition to the paresis already present in the facial region, no new disturbances of innervation appeared; but stereognosis was somewhat impaired in the left hand, although only to a slight degree. Subjectively the patient experienced for a considerable time paresthesiæ in the left half of the face and in the left hand.

A fortnight after the operation the facial paresis could no longer be demonstrated, nor the disturbance of the stereognostic sense in

the left hand. In other words, this case represented a complete cure.

On March 10th he returned to his activities as a manufacturer, of which he was soon able to take full control. On June 18th we were able to demonstrate by personal examination the fact that he was entirely well. In spite of a severe influenza at the beginning of July, the patient remained the same. At the last examination, in March, 1913, the healthy and physically active patient showed no disturbance whatsoever.

NEOPLASMS OF THE TEMPORAL LOBE AND THE ISLAND OF REIL

The temporal lobe fills the middle fossa of the skull, but its posterior portion for a considerable distance rests upon the tentorium cerebelli. At this point it goes over into the occipital lobe and farther up into the lower part of the parietal lobe.

Neoplasms of the right and left temporal lobe showed marked differences. As has already been pointed out on page 527, in right-handed persons the centers of speech, motor as well as sensory, which lie in the neighborhood of the fissure of Sylvius, occur only in the left hemisphere, while in left-handed persons they occur in the right half of the brain. Accordingly, except in the left-handed, who are relatively infrequent, the right temporal region is, like the anterior section of the two frontal lobes, a mute region, and it is when disease in this region involves the surrounding portions of the brain such as the operculum and the base of the central convolutions on the one side, or the deep-lying visual tracks on the other, directly or indirectly, that characteristic local symptoms such as hemiparesis, hemianesthesia or hemianopsia occur. In this connection Wernicke has pointed out that ptosis or dilatation of the pupil may occur on the same side as the result of pressure on the trunk of the motor oculi nerve.

APHASIA

In tumors in the left temporal lobe, in accordance with the statements already made, aphasia is the rule, and without this important symptom one can hardly localize a lesion in this lobe. But aphasic disturbances are induced by disease in various other portions of the brain, and they may be separated into two large groups. One concerns the ability to innervate in ordered succession the muscles

necessary for speech. The other includes aphasic disturbances properly speaking. The first form, the disturbances in the formation of words, anarthria, occurs in every affection of the nerve tracks which go to the muscles of speech.

In the second large group, the aphasic disturbances properly speaking, we differentiate motor or expressive aphasia (loss of articulate speech, word dumbness—see Fig. 519, No. 2 red), and the sensory or perceptive aphasia, in which the intelligent understanding of speech is lost. Usually at the same time paraphasia occurs, the patient blunders and uses words that do not apply, but which often have a sound similar to the words intended; or the disturbance expresses itself in an interchange of single letters. The sensory speech center (of Wernicke) lies in the posterior section of the superior temporal convolution (see Fig. 519, No. 11, red), and accordingly in diseases of the temporal lobe we usually have to do with this form of aphasia.

In relation to aphasic manifestations stand the disturbances in the ability to read, write, and figure. These occur in lesions of the left parietal lobe and will be considered under that head.

In addition to sensory aphasia in disease within the left temporal lobe, there is also observed a psychic deafness (acoustic agnosia). In this condition not only the sounds of speech, but other noises and sounds, for instance the tones of instruments and the noises made by animals, are not comprehended.

Finally, there must be mentioned hallucinatory sensations in the field of smell and taste that are usually ascribed to the involvement by a tumor of the medially situated sections of the temporal lobe, that is to say the most anterior portion of the hippocampal gyrus, with the uncus.

The *island of Reil* lies surrounded by the motor and sensory speech centers in the depths of the fossa of Sylvius. For this reason a new growth within its boundaries may cause as neighborhood symptoms disturbances of speech of various sorts. The aphasia will show a predominatingly motor or sensory character depending on whether the growth of the tumor is directed toward the frontal brain or toward the upper temporal convolution. Moreover, the anterior section of the cortex of the island appears to belong directly to the motor speech center, and finally through a growth in the island region the fibers of connection between the cortex of the island and the lenticular nucleus may be interrupted

—two additional factors which may give rise to aphasic symptoms. It is common property of all disease foci in the island region to give rise to disturbances in the power of expressive speech.

EXPOSURE OF THE TEMPORAL LOBE

For exposure of the temporal lobe the hemostatic suture is begun just above the origin of the concha of the ear, is carried horizontally backward, and then carried upward anteriorly and posteriorly at practically a right angle. In making the anterior bony incision one must be careful that the lesser wing of the sphenoid does not possess an angle which projects sharply inward. After the three bony incisions are completed, the bony flap is pried up with a blunt dissector introduced at the upper incision, and is broken downward with the modified Langenbeck bone forceps. This can be done readily on account of the thinness of the bone in the temporal fossa.

To mobilize the flap sufficiently the anterior and posterior incisions in the soft parts are now lengthened downward, if necessary through the line of hemostatic suture. The temporal muscle is seized with a volsellum so that the bony plate is drawn way downward, and the lamella of bone which remains projecting below can be broken away to the base of the skull just as in the operation for removal of the Gasserian ganglion (Vol. I, p. 240). In case of necessity, the osteoplastic opening may be enlarged in front or behind, removing the periosteum and breaking away the bone.

More frequently than in other portions of the skull, the bleeding branches of the middle meningeal artery must be tied off with catgut on a needle. If a branch of the middle meningeal which runs in a bony canal instead of in a furrow is torn and bleeds, it is seized with a fine hemostat and tied off.

As an example of the extirpation of a new growth in the region of the left island of Reil and of the first temporal convolution, we give the following case.

A thirty-seven-year-old woman began to complain, in September, 1907, of increasing headaches, which were first noticed in the preceding May, particularly over the left eye and in the left temporofrontal region. She also complained of loss of memory, disturbances of speech, attacks of vertigo and depression. The disturbances of speech must have been in the first place of vague character, as at that time the probable diagnosis was dementia paralytica. During the attacks of severe headache and vomiting the pulse slowed down

to 60 beats per minute, and lumbar puncture showed nothing abnormal except a moderate increase in pressure.

Oppenheim examined the patient for the first time on November 3, 1907; his findings may be summarized as follows: There existed a considerable degree of aphasia, chiefly of a sensory and amnesic character. Many questions and requests the patient did not understand, for many objects and ideas she found no words, while at times she could utter a complete sentence. Reading was mechanical without comprehension of what she read and without recognition of printed words; in trying to write, letters were interchanged. There was no hemianopsia, but choked disc was present on both sides, more strongly on the left. There was also tenderness on pressure and decreased resonance in the left temporal region, and definite paresis of the oral branches of the facial nerve on the right. Otherwise neither motor nor sensory disturbances could be demonstrated on the right side of the body. Oppenheim made the diagnosis of tumor in the left cerebral hemisphere, probably in the left temporal lobe.

On November 5, 1907, we found her suffering from rather severe manifestations of increased intracranial tension, with a pulse which at times was as low as 60, together with a rapidly increasing stupefaction, so that we performed the first stage of the operation on November 8th, with the purpose of exposing the upper temporal convolution, the fissure of Sylvius and the neighboring brain substance. A skin and bone flap, almost square in shape, each side measuring 80 mm., was formed in the temporal region, with its pedicle just above the zygoma.

A hardened area the size of a finger nail could be felt on the exposed dura which was under strong tension, and showed hardly any pulsation; otherwise there was nothing pathological. Corresponding in location to the fissure of Sylvius, which had been marked with a caustic pencil on the scalp, a depression several centimeters long was found in the dura, and the hard area lay close behind the beginning of the fissure of Sylvius.

The patient bore the first stage of the operation well, but on account of the rapidly increasing intracranial tension the dura mater had to be opened and the tumor extirpated on the following day without anesthesia; to our operative manipulations the patient did not react; she continued in a state of profound somnolence.

The tension of the dura was still higher than before, and no

pulsation was to be made out. On turning down the dural flap it was found that one small place not larger than a pea was attached to a process of tissue which resembled brain substance and which proceeded into the depths. First the dura was freed from this formation, so that it might be turned down as far as the lower margin of the opening. A flat surface the size of a pea (see Figs. 532 and 533), which projected in the anterior section of the fossa of Sylvius beyond the level of the surrounding convolutions, which were flattened and almost dry, corresponded to the hard area

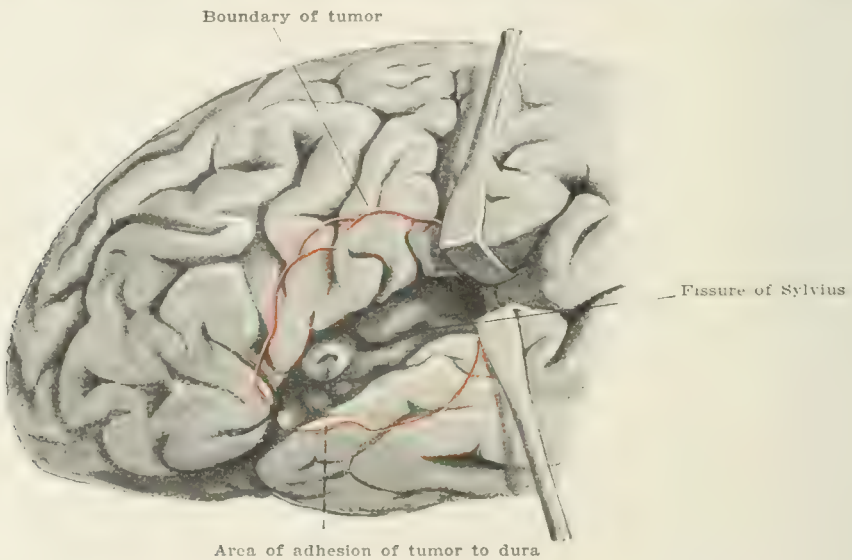


FIG. 532

Normal brain, in which the extirpated tumor has been placed in a situation corresponding to that which it occupied.

which was felt before the dura was opened, while the tender point was located somewhat higher up.

This projecting process felt somewhat more firm than normal brain substance. It continued into the depths as a large tumor which was covered above by the operculum, and was in relation below with the first temporal convolution which had been remarkably compressed; medially it had progressed as far as the island of Reil. With the index finger the rather firm and nodular encapsulated tumor could be pried out from the bottom of the fossa of Sylvius without much trouble and dislocated onto the surface of the brain. From the tumor bed, which was 50 mm. wide and of about the same depth, bright blood welled up in rhythmic

pulsation; the artery which, according to the moderate amount of the hemorrhage was judged to be a branch of the artery of the fossa of Sylvius, could not be seized in the brain tissue, but the hemorrhage ceased upon packing and light compression. The displaced tumor hung only by two arachnoidal vessels which ran into it, and after these were tied and divided the tumor was free.

Retracting the edges of the cavity which was left behind, it was carefully examined without finding any remnants of tumor tissue.

FIG. 533

Base of the skull, showing the tumor placed in the position it originally occupied.

The place on the dura where the tumor had been attached was excised by a wide margin. A small strip of vioform gauze was left in the bed of the tumor, the walls of which rapidly fell together, and was carried out at the anterior lower corner of the wound, and a short drain was introduced alongside it. The remnant of the dura was turned down over the brain, but covered only a very small area of it, for as the result of the marked edema, the brain, without pulsating, protruded for a considerable distance through the bony opening, so that the skin and bone flap could only be sewed in under considerable tension. A dural plastic was not carried out.

The projecting process, as well as the greater part of the tumor, lay exactly in the middle of the operative field from before backward; from above downward it lay at the junction of the middle and lower thirds of the bony opening. The tumor had the following dimensions: sagittally 60, vertically 50, horizontally 43 cm. When laid in the base of the skull (see Fig. 533) it practically entirely filled the middle fossa. Microscopically it was found to be sarcoma.

The technique described can naturally only be carried out if a new growth can be definitely differentiated by its consistency from the surrounding brain substance. In this case the difference was unusually evident because the portions of the brain surrounding the tumor had softened down somewhat.

The patient bore the severe operation well. The convalescence was afebrile and she rapidly recovered from her somnolence. The gauze packing was removed on the fifth day, but on account of the superficial necrosis of the brain substance surrounding the tumor, the drain had to be left in. On the evening following the second stage of the operation, the patient moved her left hand and was able to grip with it as well. The right arm was completely paralyzed, as was the right side of the face. The right leg, which was rather stiff, showed spastic manifestations. The eyes deviated and the speech was entirely gone. The pulse was accelerated, varying between 96 and 120.

By November 29th ophthalmoscopic examination showed the fundi to be normal. On the left the papilla was still somewhat grayish-red, but the prominence was almost gone. After the middle of December active motility of the limbs on the right side returned, particularly in the right arm, and this improvement increased rapidly. The disturbances of sensibility also disappeared. On January 7th the patient first attempted to walk, and on January 18th menstruation again appeared, for the first time after operation.

Speech returned very slowly. During February the patient had instruction in talking, and on February 22d she was able to understand complicated questions and also single requests. She was able to designate objects and parts of the body on examination, but only if someone gave the first sound or the first syllable of the word. Some words and sentences she occasionally uttered spontaneously when mentally abstracted or in a state of excitement.

Meanwhile the large wound had closed, except for the small

Extirpation of a recurrent tumor of the left temporal lobe.

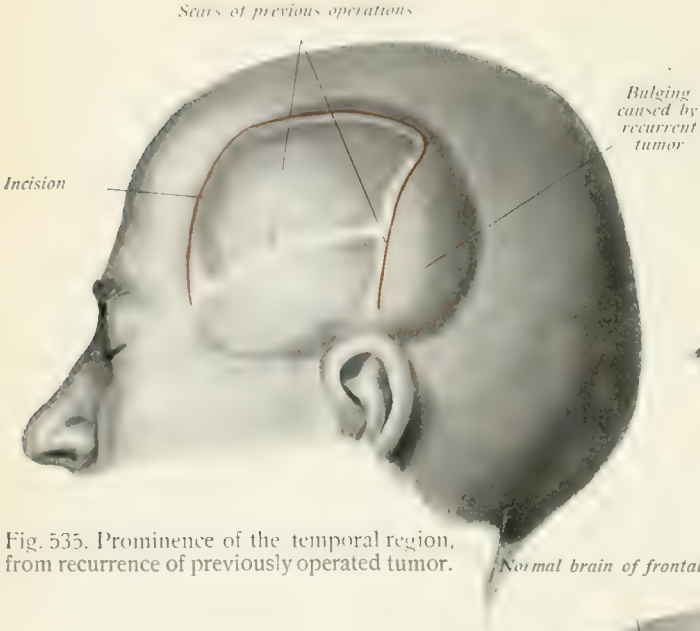


Fig. 535. Prominence of the temporal region, from recurrence of previously operated tumor.

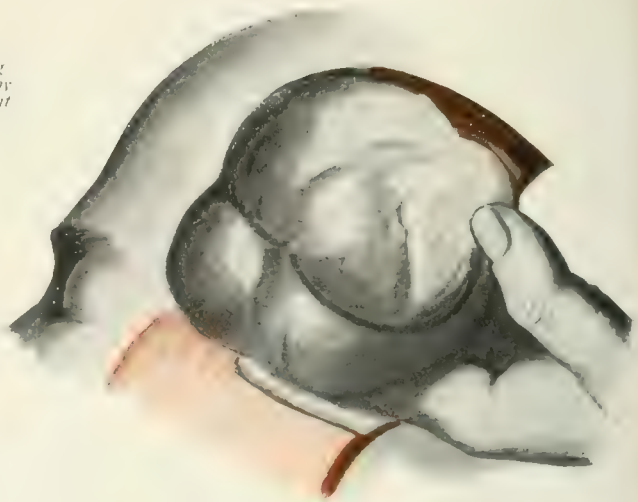


Fig. 536. The tumor is enucleated with the index finger.

Fig. 537. The osteoplastic opening is enlarged in front, above and below.

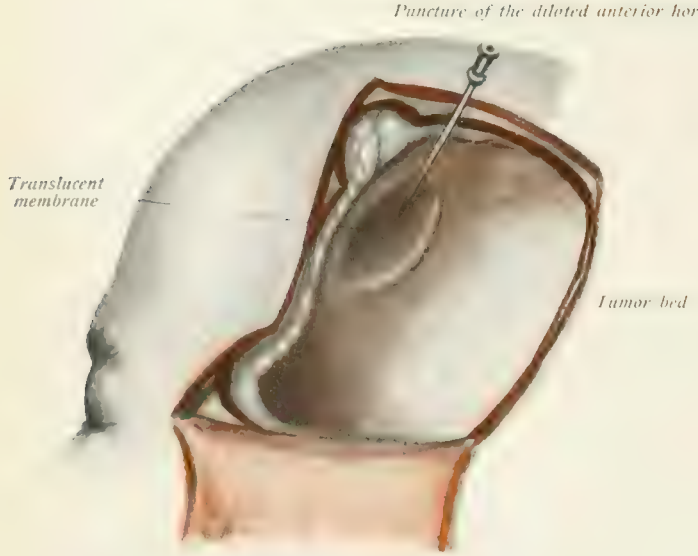


Fig. 538. Cystic swelling in the depths of the tumor bed (lateral ventricle).

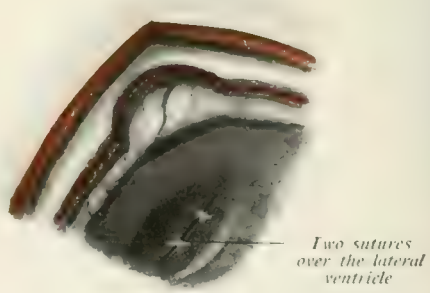


Fig. 539. Suture of the opened ventricle.

opening in the anterior lower corner where the packing had been inserted, by first intention. At this place a fistula remained, which did not heal in spite of the fact that brain substance had come away, and it had to be kept open with a fine drainage-tube. If this were removed after a few hours, and on one occasion on the next day, clonic contractions began in the distribution of the facial nerve on the opposite side, and at times the hand and forearm also participated.

Eleven and one-half weeks after extirpation of the tumor, on January 28, 1908, we exposed this portion of the bony plate by an incision made in the obliquely horizontal direction of the drain, opened up the entire fistulous track, and resected a strip from the bony plate with the Gigli saw (see the horizontal scar on Plate 92, Fig. 535).

The wound healed within a short time and the patient was discharged in a good state of health to her household duties.

On July 12, 1908, her personal physician was summoned on account of the sudden appearance of severe symptoms with vomiting and headache in the scar, as well as all the signs of a right-sided facial paresis. The left fundus showed a choked disc, and speech was impaired. The temperature reached 99, but the pulse did not show any increase in tension. The bony plate in the scar, which had previously been depressed, was now bulging. On palpation a sense of fluctuation was felt in the anterior and posterior portions of the scar; the two spaces apparently communicated. The bony plate yielded under pressure with the finger, giving the same sensation as of a solid body being pushed up and down upon a water cushion.

On July 16, 1908, we opened the old scar for the removal of the recurrence which was evidently present, and removed the upper two-thirds of the bony plate. Immediately a smooth nodular tumor came into view, which seemed to be covered with a very thin layer of brain substance. As its consistency was firmer than the brain mass, it could readily be removed. The tumor was of about the same size as the one which had previously been removed, it measured 43 by 55 by 60 mm. It possessed the same configuration and showed the same characteristics on pathological examination; it did not, however, possess the pedicle-like process by which the first one was attached to the dura.

The skin wound was sutured without drainage and healed by first

intention. The patient recovered from her second operation completely within three weeks, and the paresis and the choked disc disappeared.

The expectation that the cure would be permanent after the second operation was not fulfilled. On March 8, 1909, Oppenheim was able to demonstrate a true apraxia of the right hand; the patient could not, for example, make threatening motions with this hand, although she could do it well with the other. There was also analgesia of the right hand; contacts were not perceived here by the patient. The sense of pain was retained in the right leg; nevertheless, the tendon phenomenon was exaggerated, and the Babinski and Oppenheim reflexes were present. Communication was rendered difficult because she did not comprehend everything. She repeated fairly well what was said to her. At a bulging place in the bone on the left side just over the ear, pressure elicited severe pain. Not only had the previously existing depression disappeared within the space of ten days, but the entire temporal region had become rather prominent (Fig. 535, Plate 92).

Taking everything together, these manifestations could be interpreted only as meaning a second recurrence. The general condition of the patient being excellent, following her own desire and the entreaties of her relatives, we performed a third operation on March 11, 1909.

Under chloroform anesthesia we made an incision all around the old scar and proceeded carefully into the depths at the upper margin of the wound, until brain substance came into view. This appeared somewhat more yellow than normal. Then we carefully dissected the skin flap away from the brain over the upper two-thirds, directing the strokes of the knife toward the skin, exposing in the process the remnant of the bony plate, which we then completely removed.

In this region a grayish-red soft neoplasm made its appearance from behind forward, which unquestionably had altered its character since the previous operation. In the anterior lower corner of the wound, and somewhat toward the base, another callous place had to be cut through. Then the tumor became visible over a larger area. After the covering layer of brain had been divided sagittally over its center, the tumor could be enucleated with the finger which was inserted with great care behind and above (Fig. 536, Plate 92). It extended into the medullary layer and had formed a large cavity; it was about the size of a kidney, but thicker.

A process was seen to extend inward, downward and forward into the depths. The incision, accordingly, had to be extended downward and inward at an angle of 45 degrees at one corner of the wound, and after displacing backward the soft parts, the bone was removed over an area the size of a half dollar (Fig. 537, Plate 92). The osteoplastic opening now extended for some distance into the anterior fossa.

As the tumor appeared to extend also forward and upward, a piece of bone of similar size had also to be removed from the frontal opening in the anterior upper corner with rongeurs. The dura had been preserved here, but on account of the danger of recurrence, it was cut away, as the tumor came within its immedi-

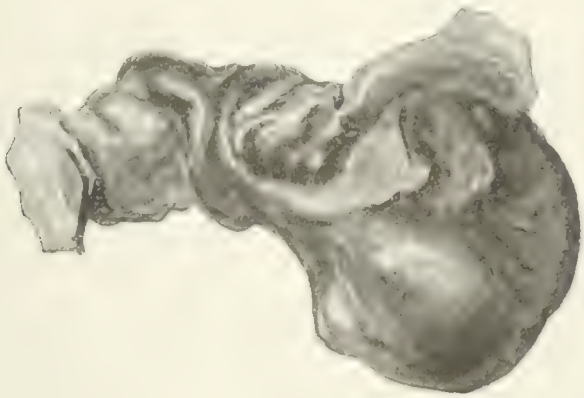


FIG. 534
Extirpated tumor (second recurrence).

ate neighborhood. Thereupon the middle section of the normal frontal brain came into view (Fig. 537).

The brain mass was then displaced forward with a blunt dissector and divided with scissors. Above the tumor could now be removed from the frontal brain tissue, but it extended some ways further forward and downward under the cortex. At this place a large process proceeded toward the base of the brain. Accordingly a considerable portion of bone had still to be removed in front and below (Fig. 537). The tumor could now be enucleated at the base. But way forward and below, a large node connected with the bone and dura, to the latter of which it had become inseparably attached, had to be cut out. At this point several meningeal branches spurted and had to be tied off.

We could now say definitely that everywhere, even in the deep

cavity downward and forward, only normal brain substance was to be seen, so that the extirpation on this occasion also seemed to be a radical one. The incision in the soft parts extended forward finally to the margin of the left eyebrow, and the defect in the bone extended to a line drawn perpendicularly through the middle of the eyebrow.

In examining the cavity in the brain, which was somewhat larger than a fist, and especially in the neighborhood where the central region goes over into the frontal brain, no further tumor tissue could be discovered. However, in the anterior third of the medial floor of the cavity a floating translucent bluish membrane about the size of a quarter dollar was seen (Fig. 538, Plate 92). On puncture and aspiration a clear fluid was obtained. For the sake of assurance, an incision was made to determine whether this represented a portion of the tumor which had undergone cystic degeneration. After the edges of the incision were held apart by small blunt retractors, it was found that the widely dilated anterior horn of the lateral ventricle had been opened and that its walls were normal.

In order to avoid a dangerous flow of cerebro-spinal fluid, the incision was closed by two interrupted linen sutures (Fig. 539, Plate 92). A process of the tumor had accordingly advanced as far as the lateral ventricle, and would have soon penetrated into this, with a resulting rapid dissemination of the neoplasm.

The suture of the lateral ventricle was entirely successful; for after the operation no cerebro-spinal fluid drained away, and the enormous hole, after the flap of skin and soft parts had been sewed over it, healed by first intention, without temperature reaction. On the first two evenings the pulse reached 120 and 110, and then it fell to 74.

The patient stood the severe operation well. It is worthy of note that after operation paralysis developed only in the hand and fingers of the right side, while active movements could be carried out in the shoulder and elbow joints and in the leg, as well as before the operation.

On examination April 11, weak active movements appeared in the wrist and fingers. The patient could also feel here the touch of a camel's-hair brush, but it was falsely localized. The patient could make herself understood chiefly through gestures or by those about her continuing to ask questions until she said yes to the right one. In answering questions, she sometimes said yes when

she meant no, but not very often. Written requests she only partly understood. She could not write spontaneously either with right or left hand, nor upon dictation, but she copied with fair success. The mental activity did not seem to be diminished over her former condition. The patient soon began to play chess again. Requests to perform definite acts were rightly carried out, practically without exception.

In April, 1909, the patient was discharged home. The site of operation was satisfactorily healed, but there persisted a deep depression. The general condition was good and she could walk with

FIG. 540

Appearance of the patient, June 6, 1909; photograph.

support. The ability to use the right arm had increased markedly; the patient could even move the individual fingers, although slowly and incompletely. The facial paralysis had likewise almost completely disappeared (Fig. 540).

She continued in a good state of health until the end of September, 1909. In the middle of October, the depression in the skull seemed somewhat more shallow, and recurrence was undoubted. On March 10, 1910, that is to say, exactly a year after the last operation, the externally visible tumor was the size of a fist. On May 19, 1910, we found the tumor already developed to an enormous size; in its lower section it was firm and nodular, but in its upper portion it evidently contained fluid. In the course of the next few

weeks the paresis in the right arm and leg increased somewhat, so that it became troublesome. By July 20, as the result of what had become a very rapid growth, the tumor had doubled in size. On account of the great weight of the tumor mass, the patient could no longer support her head, and accordingly had remained in bed for the preceding fortnight. On September 22, 1910, she died, under conditions of rising temperature and pulse rate and increasing stupor.

Section of the brain (Dr. Ostreich) revealed the following conditions: No meningitis; the left hemisphere was crowded out of place by an enormously large tumor, which extended forward as far as the frontal pole and backward within 5 cm. of the occipital pole. The entire length of the tumor mass from before backward was 25 cm., the width in the occipital region 13 cm., and in the frontal region 10 cm. It gave the impression of a third hemisphere considerably larger than either of the other two. While the right hemisphere remained intact, only a strip 5 cm. wide was left of the left hemisphere.

EXPOSURE OF THE LATERAL VENTRICLE

We have had to open the lateral ventricle as described in this case report, several times in the removal of recurrent brain tumors, as has already been described in the chapter on Operative Treatment of Epilepsy (see p. 496). For example, in a thirty-eight-year-old man, after removing a tumor mass, which for the most part showed cystic degeneration, we found the brain substance presenting a bluish discoloration and blown up like a bladder, in the region of the boundary between the parietal and occipital lobes. On opening the cysts and removing their walls for microscopic examination, we ventured into a remarkably dilated lateral ventricle. From the floor there projected upward into the ventricular space a grayish-red nodular tumor which, according to its form and position, could arise only from the large basal ganglion.

On retracting the walls of the ventricle with blunt hooks, the tumor was rendered visible over its entire extent. It went over without a sharp line of demarcation into the brain substance, from which it could be barely differentiated by its consistency on palpation. It bled very actively on its surface immediately on being touched with a blunt hook, so that it had to be considered as richly supplied with blood; the bleeding area was closed in with two

sutures. As it appeared impossible to continue the extirpation under moderately strong compression upon the brain mass, the wounds were closed.

The operation affected the patient so slightly that within four days he was taking his meals sitting up in bed, and two days later he was walking around the corridor of the hospital on the arm of a companion.

The pulse rate on the evening of operation rose from 76 to 96, on the next morning to 104, and on the evening to 108; but on the next day it fell to 96 and then to 84, and thereafter it was normal. The temperature taken in the axilla, which previously had never risen beyond 99, rose at corresponding periods to 99.8, 100.4, 101, and then fell to 99.5 in the evening, 98.6 and 98.4 in the morning. There was a moderate flow of cerebro-spinal fluid for the first ten days, so that the superficial layers of the dressing had to be renewed daily; later the flow of fluid diminished and it stopped altogether at the beginning of the third week. The wound, which had not been drained, healed by first intention; the cerebro-spinal fluid came out in a few drops through some of the suture holes, which healed over very rapidly upon cessation of the flow. Sixteen days after the operation the patient, subjectively much improved, journeyed back to his home.

Such repeated circumstances have convinced us that opening the ventricle wide is entirely without danger, it being understood that the strictest asepsis is observed. We have also exposed the fourth ventricle for complete examination and have obtained healing (see p. 631, following).

On September 19, 1903, we extirpated with good result a *tumor in the region of the optic thalamus* in a twenty-four-year-old woman, which had been diagnosed by Oppenheim. Through an incision 3 cm. long in the temporal lobe, we came down upon the smooth capsulated fibro-sarcoma about half the size of a small apple, at a depth of 5 cm. measured from the surface of the brain, and were able to shell it out by shoving to one side the palpable vessels with the two index fingers, in which process we had to proceed to a depth of 9 cm. The wound was healed by October 6, and the general condition was good. This case will be reported in fuller detail later.

NEOPLASMS IN THE PARIETAL LOBE

The parietal lobe is the middle portion of the cerebral hemisphere, bordering on all the other lobes; its boundaries are relatively indistinct. It is divided by the interparietal sulcus into a superior and an inferior parietal lobule. Each is made up of a number of small and irregular convolutions to two of which, in the inferior parietal lobule, names have been given, the supramarginal gyrus and the angular gyrus.

INVOLVEMENT OF THE CENTRAL INNERVATION OF THE OPPOSITE SIDE OF THE BODY

The parietal lobe of the brain, just like the sensomotor region, takes part in the central innervation of the opposite side of the body. Accordingly, just as in lesions of the central region disturbances of deep sensibility occur, so also in lesions of the upper parietal lobe and in the neighboring supramarginal gyrus, disturbances in the sense of position, and in stereognosis of the hand of the other side of the body are observed, as well as ataxia of this limb. Foci in the middle third of the posterior central gyrus and in the adjacent region of the lower parietal lobe occasion loss of tactile sense (see p. 542).

ALEXIA, AGRAPHIA, AND HEMIANOPSIA

The angular gyrus of the left hemisphere is in right-handed persons the seat for the recognition and interpretation of written or printed signs. It stands in relation on one side with the visual cortical center in the occipital lobe, and on the other with the sensory speech center in the upper temporal lobe. If the left angular gyrus is disturbed by a new growth, or if its function is interfered with, the ability to read is disturbed and alexia or word-blindness results.

However, these symptoms may vary, according as the focus of disease is superficially or deeply situated. Neoplasms which have their location in the angular gyrus just behind the sensory speech center, induce, in so far as they are situated in the superficial medullary layer near the cortex, at the same time grave disturbances in reading and writing,—alexia and agraphia (see Fig. 519, p. 529, No. 12, blue), while the other speech functions are only slightly involved in the form of light paraphasia and an increased difficulty

in selecting words. At the same time in deep-seated lesions hemianopsia practically never occurs.

Neoplasms in the deep medullary layers of the angular gyrus near the median surface of the brain cause a pure alexia, that is to say, loss of the ability to read, while the ability to write is not interfered with. As the optic radiation has its situation in the depths of the angular gyrus, it may be affected directly or indirectly by disease foci; hemianopsia then results (cf. p. 564).

APRAXIA

Apractic disturbances, concerning the knowledge of which we owe so much to Liepmann, are in many ways comparable to the aphasic symptoms. Apraxia in right-handed persons occurs particularly in lesions in the left hemisphere, and accordingly is usually met with in its highest degree in the right hand. Liepmann shows that ordinarily, in addition to severe apractic disturbances in the right hand, slight dispractic disturbances may appear in the left. From this it is to be concluded that the left hemisphere in complicated movements, particularly in movements depending upon memory, exercises a leading influence upon the right hemisphere, and therefore upon the left hand. Accordingly, if a lesion is so situated in the left hemisphere that the right hand becomes not only apractic but also paralyzed, then apractic symptoms appear in the unparalyzed left hand, particularly in movements stimulated by memory and in imitative movements.

The patient can no longer threaten, gesture, salute, or thumb his nose; he cannot count money in an orderly fashion, nor can he strike a match or light a cigar properly, or use the toothbrush, or execute similar movements. Also, if these movements are properly performed for him, he cannot imitate them. Furthermore, he cannot execute the movement for catching a fly, for knocking on the door, or for playing a hand organ, and so on. Since the corpus callosum transmits the direct impulses which the left hemisphere gives the right during action, accordingly large lesions in the corpus callosum induce a dispraxia of the left hand without involving the right in the least. In this connection the middle third of the corpus callosum is particularly likely to induce this phenomenon. In a series of cases, tumors or softening in this region of the corpus callosum have, in fact, caused an isolated dispraxia of the left hand.

If the posterior central gyrus and the portion of the parietal

lobe which lies just behind it are markedly involved, the apraxia is complicated by loss of tactile sense and disturbances of sensibility. Determination of the occurrence of apraxia then depends upon the circumstance that disturbances of movement arise which cannot be sufficiently explained by the existing disturbances of sensibility.

OPTIC APHASIA

Lesions situated at the boundary between the temporal lobe and the occipital lobe or in the most anterior section of the occipital lobe may give rise to occipital aphasia. This represents a form of amnesic aphasia. In amnesic aphasia, or verbal amnesia, the loss of spontaneous speech is not, according to Liepmann, a total one. "The ability to find words is rendered very difficult; but if the proper word is suggested, it is at once recognized as correct and is spoken." In optic aphasia objects are not defined if they are made known to the consciousness by visual or tactile sense. The right word, however, occurs immediately through the intervention of the sense of hearing, for instance, upon hearing the blowing of a trumpet.

EXPOSURE OF THE PARIETAL LOBE

The technique for exposing the parietal lobe corresponds to the general directions already given. The point at which the skull is opened is shown in Fig. 519, p. 529.

NEOPLASMS OF THE OCCIPITAL BRAIN

The occipital lobe rests directly upon the tentorium cerebelli. Upon its median surface, which lies in apposition with the falx cerebri, it is sharply divided from the parietal lobe by the parieto-occipital fissure. On its convex surface it goes over gradually into the parietal and temporal lobes (cf. Fig. 520, p. 531, Fig. 518, p. 528).

HEMIANOPSIA

The most important symptom aroused by a new growth in the occipital lobe is crossed homonymous hemianopsia; when this disturbance is present, if the lesion is on the left side the right half of the visual field of both eyes is wanting over a greater or lesser extent, and vice versa.

Hemianopsia may occur from an interruption of the visual path in any part of its course from the optic tract to the cortex of the

occipital lobe. As the fibers of communication may be affected by many forms of lesion, in making a diagnosis all other local manifestations must be carefully looked into. In hemianopsia, as a result of tumor formation in the occipital lobe, a true visual paralysis is observed on the blind half of the field. In rare instances hemianopic disturbances do not cause total blindness of the affected half of the retina, but instead, in much less intensity, hemianopic disturbances of the color sense only.

In any case relatively insignificant injuries of the posterior surface of the occipital lobe may induce temporary or permanent hemianopsia. For the cortical visual center extends on its medial surface somewhat over onto the occipital pole and the lower occipital convolution. Thus after extirpation of a perforating sarcoma of the dura above the transverse sinus, during which process the occipital pole was exposed, we have twice seen hemianopsia arise as the result of the necessary gauze packing (cf. p. 691).

Cortical blindness (or cerebral blindness) arises if both cortical visual centers at the cuneus or the visual tracks in the medullary layer of this region are destroyed, such as happens with tumors which arise from the falx cerebri. It is characteristic of this form of blindness that the pupils of both eyes are stimulated to contract by the irritation of light.

If the effect of an occipital tumor extends forward to the origin of the temporal lobe, manifestations of sensory aphasia will appear in which particularly the finding of proper words is rendered difficult.

In infrequent cases a tumor of the occipital lobe, without inducing any other characteristic symptom, particularly hemianopsia, will exercise a considerable pressure upon the tentorium cerebelli, and through it on the cerebellum. In this way many manifestations of a cerebellar tumor develop, and lead us astray in our operative treatment.

EXPOSURE OF THE OCCIPITAL REGION

The occipital region of the brain is exposed by an osteoplastic opening, the base of which is just above the external occipital protuberance and extends from the middle line horizontally outward to a point in a line with the posterior border of the mastoid process (Fig. 541). One can reach the convex as well as the medial surface; in the latter case after cutting out the dural flap it is

necessary to double-tie and divide the veins which run from the longitudinal sinus to the pia mater, or to carefully hold them to one side. In the same way it is possible to palpate the surface of the cerebrum which lies upon the tentorium cerebelli and to render it visible by lifting the brain on a spatula.

Fig. 541 shows the scar of a man of thirty-five years in whom

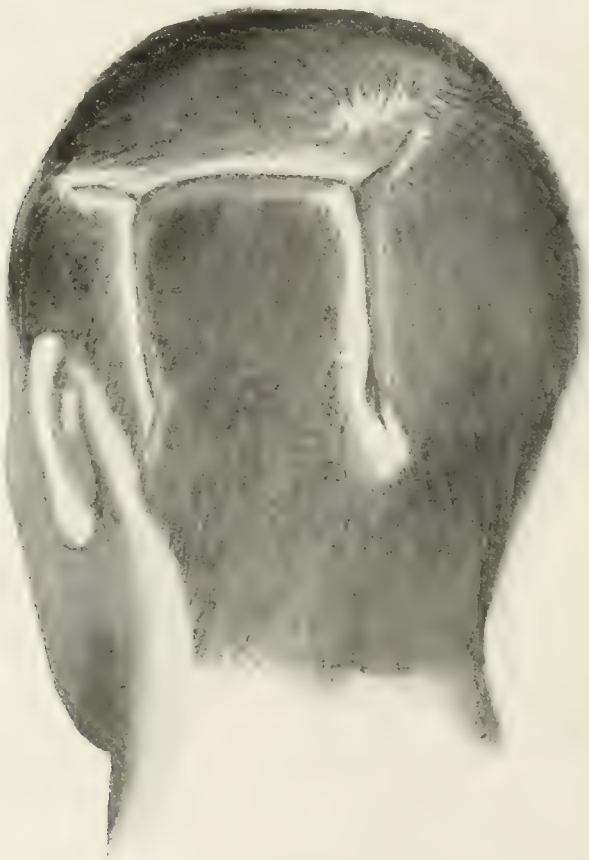


FIG. 541
Scar after exposure of the occipital brain.

in June, 1906, we extirpated in two stages a large fibro-sarcoma from the posterior pole of the occipital brain, which took its origin from the inner surface of the dura. The next figure (542) shows the inside of a skull in which the dura and all its processes have been preserved. The extirpated tumor, after hardening, has been placed in the position in which it was found in the patient.

The operation was followed by a characteristic attack of brain fever, although the removal of the tumor alone only took a few

minutes, and hardly a tablespoonful of blood was lost (Fig. 543). Evidently the sudden change in intracranial tension exerted a marked influence upon the brain. At any rate the patient on awakening from the anesthetic at eleven in the morning felt very well, but at half-past two he showed a temperature of 103 and a

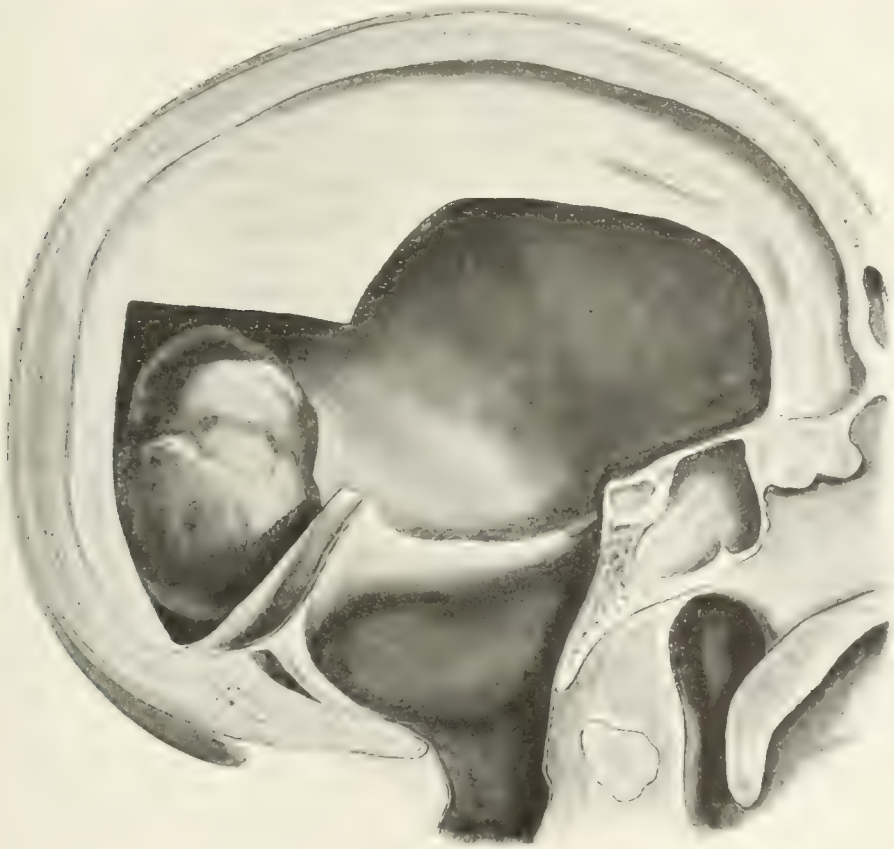


FIG. 542

Tumor of the occipital lobe, as it appeared replaced in the skull.

pulse of 146. At 6 P. M. the temperature had risen to 105.6 and the pulse to 158. At eight o'clock that night the pulse could be counted only at the carotid, but at this time the patient's temperature had returned to normal.

This condition is called brain fever, but the only thing it has in common with other fevers is the presence of a high pulse rate and febrile temperature. All other symptoms were lacking; it would be preferable to speak of it as a hyperthermia.

The patient's general condition remained critical. From time to

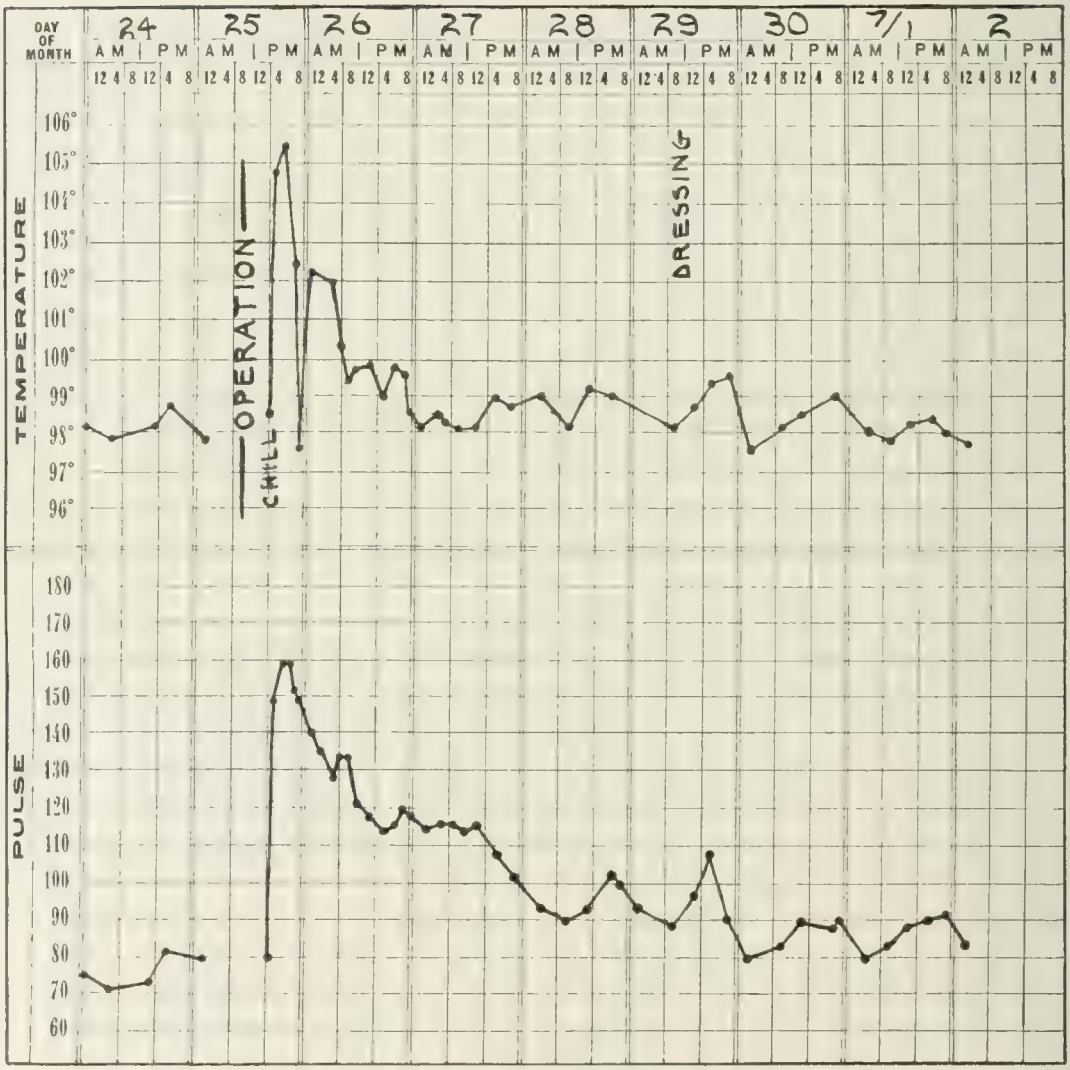


FIG. 543
Temperature chart.

time he was forgetful, but for the most part he was in good humor; he asked for nothing to drink, he did not vomit and felt subjectively very well; he said he was "feeling fine." But threatening manifestations were still present, and they exhibited themselves in a state of collapse which developed about nine o'clock with a temperature of 97.4, which at midnight reached a level again of 102.4. The pulse in four days gradually came down to normal, as did the temperature also, following this second rise. Except for the fact that the single change of dressing on the fourth day stirred up the patient somewhat, the further course was entirely normal.

Recovery has remained complete to the present day, and even the right-sided hemianopsia has disappeared.

SURGERY OF HYPOPHYSEAL TUMORS

In addition to symptoms of general cerebral compression which do not always occur, certain neighborhood symptoms, such as involvement of the olfactory nerve, the motor nerves of the eye, and the trifacial; bulging of the sella turcica, which can be seen in the X-ray plate; the clinical picture of acromegaly, which was established by Pierre Marie in 1886, and manifestations on the part of the optic chiasm are to be mentioned as characteristic of hypophyseal tumors. The pressure of a new growth upon the chiasm may totally or in part destroy the conductivity, at the anterior as well as at the posterior angle, of the medially situated and crossed fibers. As a result there occurs a more or less complete bi-temporal hemianopsia, that is to say, a loss of the temporal halves of the visual field or a portion thereof. This important symptom, however, is found not only in tumors of the hypophysis, but also in internal hydrocephalus of marked degree, if the floor of the third ventricle, bulging bladder-like downward against the base of the skull, exerts pressure upon the chiasm. Just as in such cases the hypophysis exerts pressure from above, so also an empyema of the sphenoid may cause a cavity formation in the base of the skull below, in the region of the sella turcica, and give rise to bi-temporal hemianopsia.

If the crossed lateral bundles are affected as well, the blindness involves also the temporal and the nasal halves of the visual field, and with a complete destruction of the lateral fibers of one side, total blindness occurs upon the eye of the same side, while the temporal hemianopsia persists in the other.

In addition the function of the sexual organs and the secretion of urine may be affected in hypophyseal tumors; for example, polidypsia may arise, and in many cases adiposity develops. Genital degeneration may dominate the clinical picture.

OPERATION THROUGH THE NOSE

Hypophyseal tumors may be reached through the nose. The first method employed for this purpose was that of Schloffer, which has already been described in connection with a case in Volume I,

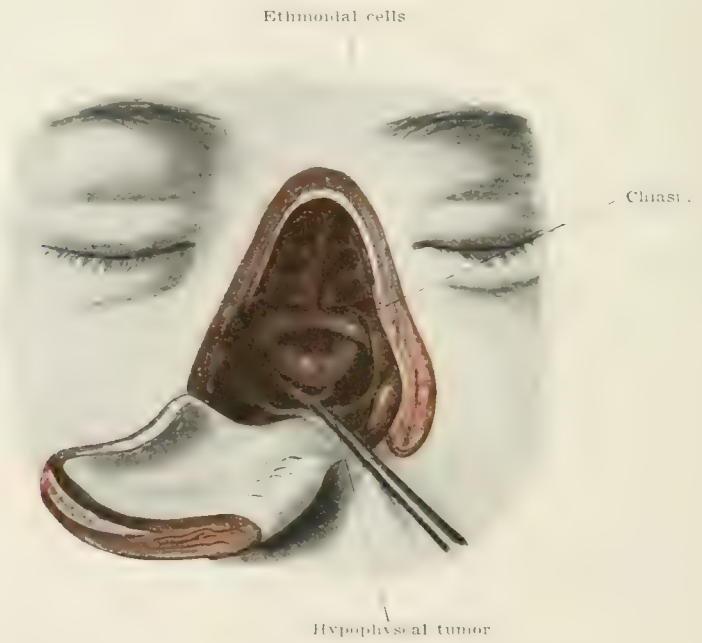


FIG. 544
Hypophyseal tumor, exposed by the method of Schloffer.

p. 191, ff. This technique is excellent for small and particularly for cystic tumors, and we have satisfied ourselves of its usefulness and practicability by nine extirpations. In favorable cases one can readily succeed in rendering the chiasm visible to the eye, as is shown by the following picture (Fig. 544) which was sketched by the artist during the course of an operation.

The Schloffer operation cannot be regarded as particularly dangerous. In our nine cases, we lost only the last one, a thirty-year-old patient in whom the operation was undertaken under novocain-suprarenin anesthesia. He died on the evening of the day of

operation from cardiac paralysis, and at autopsy there was found a dilated ventricle, sub-endocardial hemorrhage and hydro-pericardium. And in this case the autopsy, which was carried out by Professor Östreich, showed that except for a very superficial hemorrhagic infiltration of the arachnoid in the region of the pons and of the medulla oblongata, the findings elsewhere in the brain were negative and that we had succeeded in removing the entire tumor, microscopically an adenoma about the size of the terminal phalanx of the index-finger, without the least injury to the neighboring structures. The other eight patients recovered from the operative procedure. Meningitis was avoided in these cases by packing with iodoform gauze, and this packing was allowed to remain undisturbed for at least ten days.

According to all our autopsy records, there can be no doubt that a true extirpation of a solid tumor from below after opening up the floor of the sella turcica is possible only in very infrequent cases. Moreover, solid hypophyseal tumors are by far the more frequent, and cystic tumors in this region are among the rarities; it is for these that the nasal approach is indicated. It is striking that we, as well as von Eiselsberg and Hochenegg have, after curetting out the sella turcica, seen the manifestations of acromegaly as well as the strong subjective symptoms and choked disc entirely disappear, and the general condition improve.

For exposing the hypophysis through the nose there are a series of other methods, of which that of Hirsch is the most elementary. We have described this in his own words in Volume I, p. 195. We have performed it but once; it differs so from the ordinary surgical technique that it requires a considerable technical training in rhinology to be able to perform it with satisfaction. It possesses the advantage over the method of Schloffer that it leaves no scar upon the face and that it never gives rise to ozena, such as sometimes occurs following Schloffer's operation. In order to prevent this it is advisable, when possible, to preserve the middle and inferior turbinates.

Harvey Cushing has developed the endo-nasal method of Hirsch to a high degree of excellence. As the result of an extensive experience he has perfected the technical details of the operation to the point where it may be considered as superseding all other methods which approach the hypophysis from below. The accompanying illustrations, taken from the Weir Mitchell lecture of

1914,* show clearly the various steps in the procedure as practiced by Cushing.

The patient lies supine on the table, with chin tilted upward. The mouth is held open and the tongue forward by means of the Sewall combined mouth gag and tongue depressor. Anesthesia is maintained by ether vapor delivered into the pharynx through a

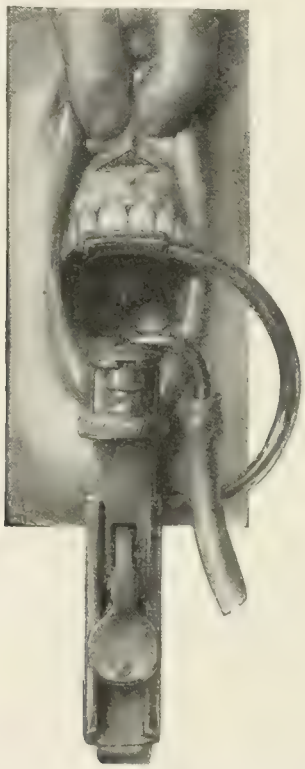


FIG. 545

Transphenoidal approach to the hypophysis. The mouth gag is in position and the small transverse Loewe-Halstead incision across the frenum has been made. (Cushing—from Jour. Amer. Med. Ass'n.)

tube soldered to the upper surface of the depressor; or the intratracheal insufflation method may be employed.

The approach to the nasal cavity is made through the mouth. The nose is drawn upward and a short transverse incision is made below the origin of the frenum of the upper lip (Fig. 545). Working upward by blunt dissection the lower edge of the cartilaginous septum is exposed (Fig. 546). The mucous membrane is elevated

* Cushing, Surgical Experiences with Pituitary Disorders, Jour. Amer. Med. Ass'n, 1914, Vol. LXIII, p. 1515.

from the septum to a considerable depth, to allow the introduction of lateral retractors (Fig. 547). The elevation is continued until the septum has been denuded over the required extent (Fig. 548),

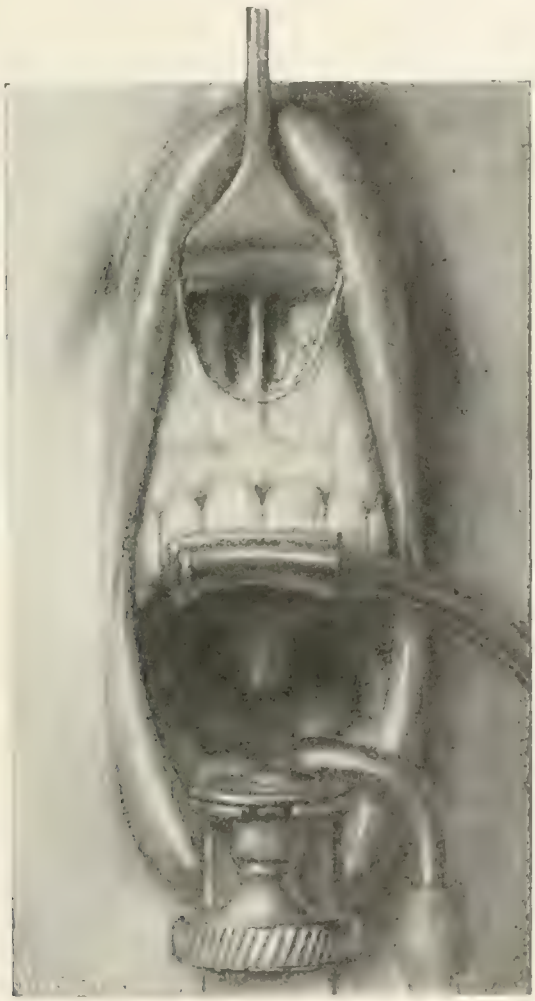


FIG. 546

The lower edge of the cartilaginous septum has been exposed by blunt dissection. The mucous membrane is elevated from the septum to a considerable depth preparatory to the introduction of the primary retractors. (Cushing—from Jour. Amer. Med. Ass'n.)

when it is removed. The Ballenger knife is used for the cartilaginous, and nasal rongeurs for the bony septum.

To render the anterior wall of the sphenoidal sinus visible, the lower turbinates are temporarily flattened against the lateral walls of the nose by forcibly introducing between the lateral retractors

a series of dilating plugs, similar to rectal dilators (Fig. 549). When the dilatation is completed, the lateral retractors are removed, and a self-retaining bivalve speculum substituted (Fig. 550). Through this, with the aid of the headlamp, one can proceed to

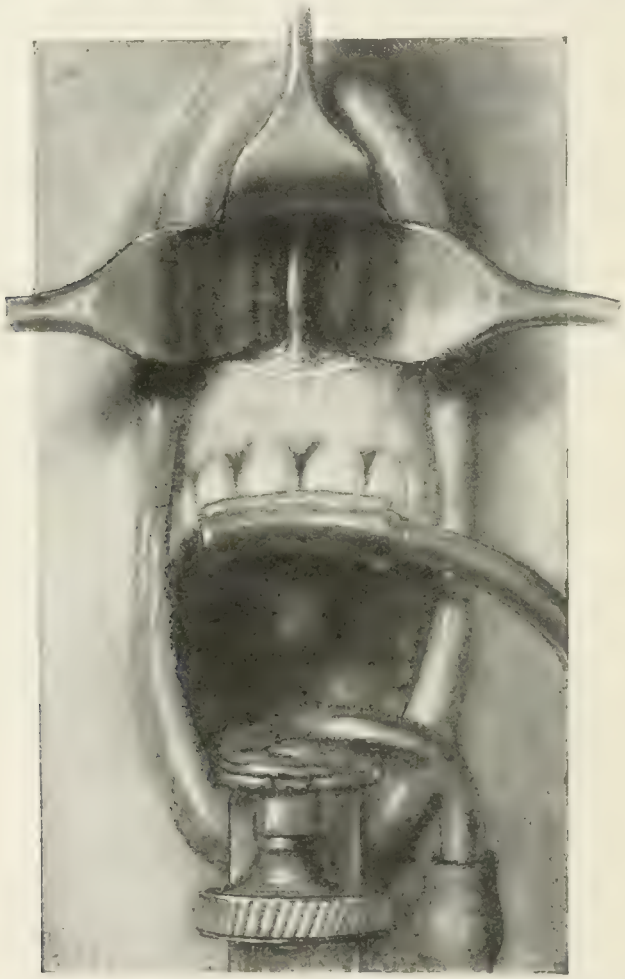


FIG. 547

The primary lateral retractors are in place. (Cushing—from Jour. Amer. Med. Ass'n.)

bite away the walls of the sphenoidal sinus with the nasal rongeurs (Fig. 551). As identification of the structures at every bite of the rongeurs is essential, the field must be absolutely dry, and this is likely at times to require tedious sponging.

"In the simple cases removal of the anterior wall of the sphenoidal cells exposes the bulging struma, which is often covered merely

by mucous membrane and distended dural capsule, with possibly a few scales of the thinned sellar base between them. On slitting the coverings the soft struma extrudes from the incision and as much of the tissue as judgment permits is scooped out of the base of the sella by a blunt spoon."

The gland must be completely dry before withdrawing from the deep operative field, as no drainage from the sphenoidal cells is provided for. The bivalve speculum is then removed, and a cigarette of gauze covered by petrolatumed gutta-percha tissue is placed in

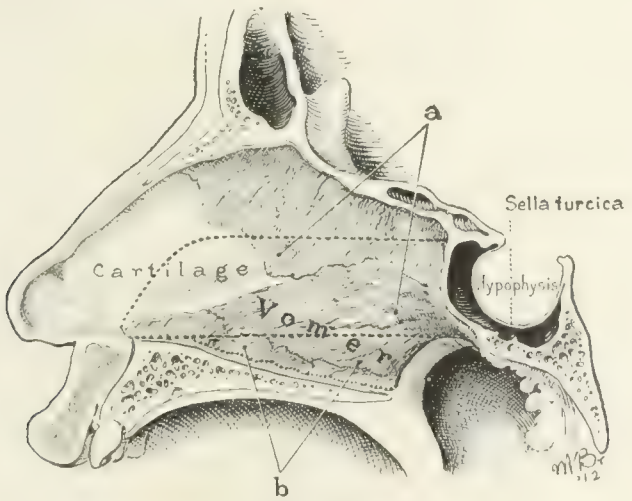


FIG. 548

Diagram to show approximately the amount of septum removed, *a* being the necessary pathway, *b* being removed in addition, to insure orientation by keeping close to nasal floor. (Cushing—from Jour. Amer. Med. Ass'n.)

each nostril to hold the two leaves of septal mucosa in approximation, and the sublabial incision is closed with two or three sutures of catgut. The plugs are removed after a few hours; the patients are usually able to leave the hospital in a week or ten days.

FRONTO-PARIETAL METHOD

But the nasal approach should not be employed if symptoms give any hint that the tumor has spread over the sella turcica to the surrounding regions of the brain, frontal or temporal, because then it cannot be removed radically by this technique. For all such cases only those methods are to be considered which reach the hypophyseal tumor by lifting up the cerebrum.

The frontal method as introduced by Krause originated in Janu-

ary, 1900, in an operative case in which we had to remove a revolver bullet from the upper surface of the roof of the orbit back near the point of entrance of the optic nerve; the twenty-year-old

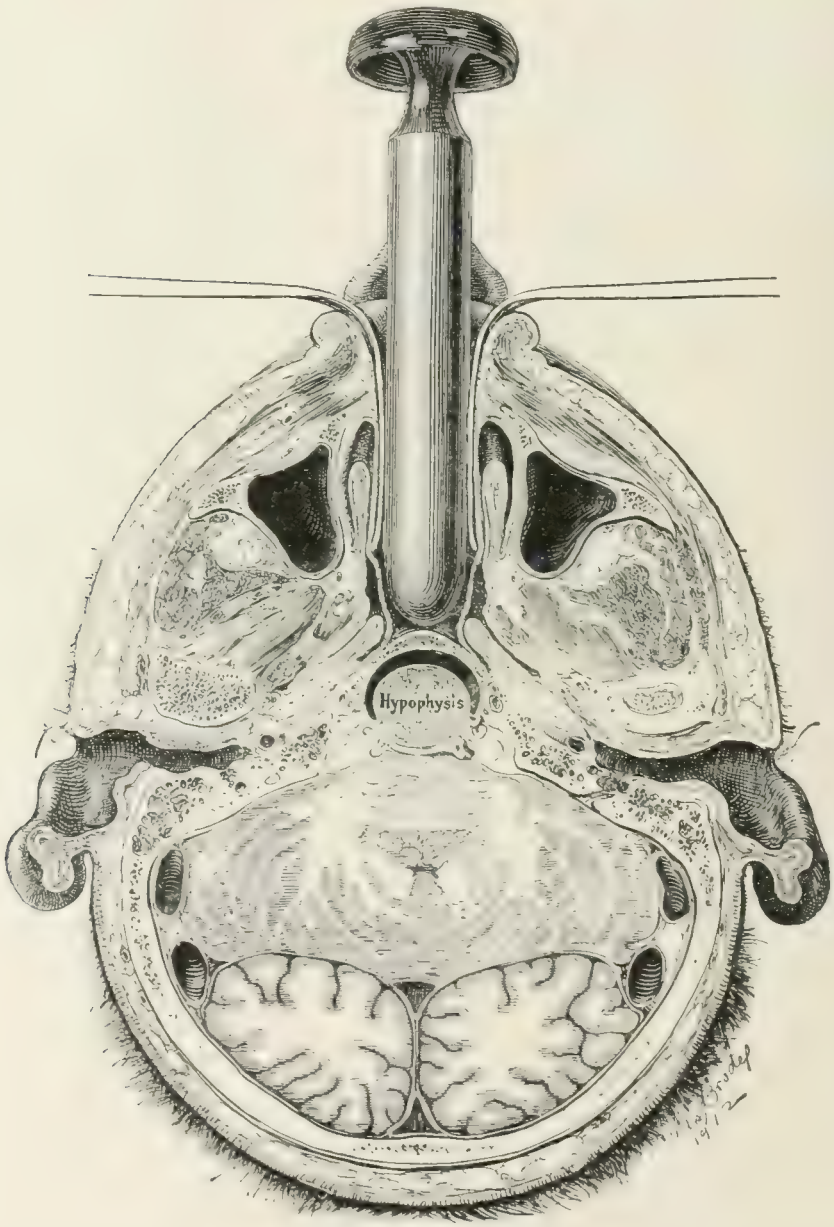


FIG. 549

Horizontal section to show introduction between the retractors of one of a series of dilating plugs which serve to flatten the turbinates. (Cushing—from Jour. Amer. Med. Ass'n.)

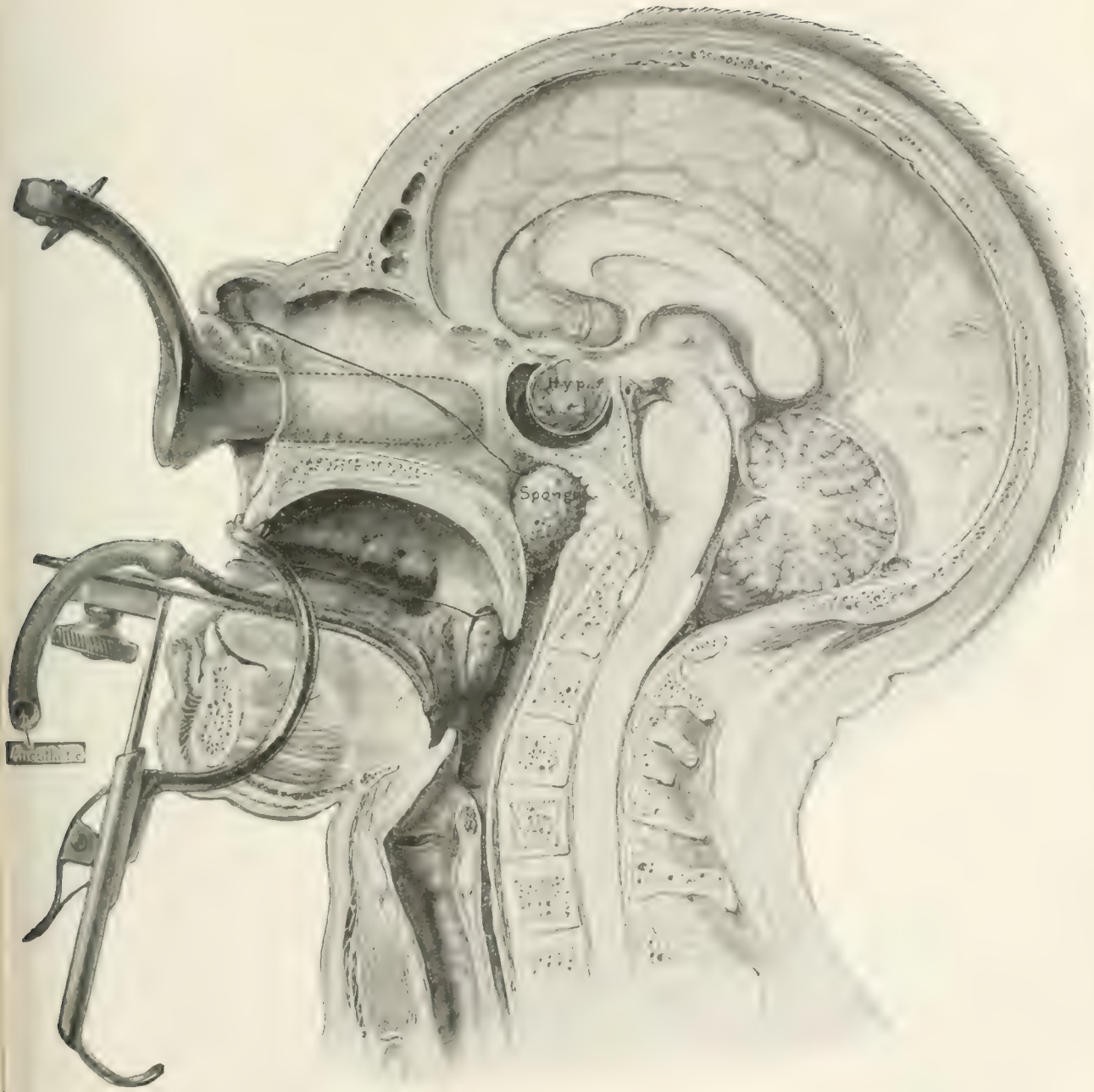


FIG. 550

Sagittal section to show position of structures and substitution for the two lateral retractors of a self-retaining bivalve speculum through which the further manipulations are conducted. (The sponge shown in the naso-pharynx is no longer used.) (Cushing—from Jour. Amer. Med. Ass'n.)

patient recovered. In removing the bullet, which had grown fast in the anterior fossa, we had to proceed as far as the optic foramen; accordingly, it was only another step to employing the same method as a way of approach to the hypophysis (Fig. 552).

Recently Bogojawlensky* and Charles H. Frazier† have em-

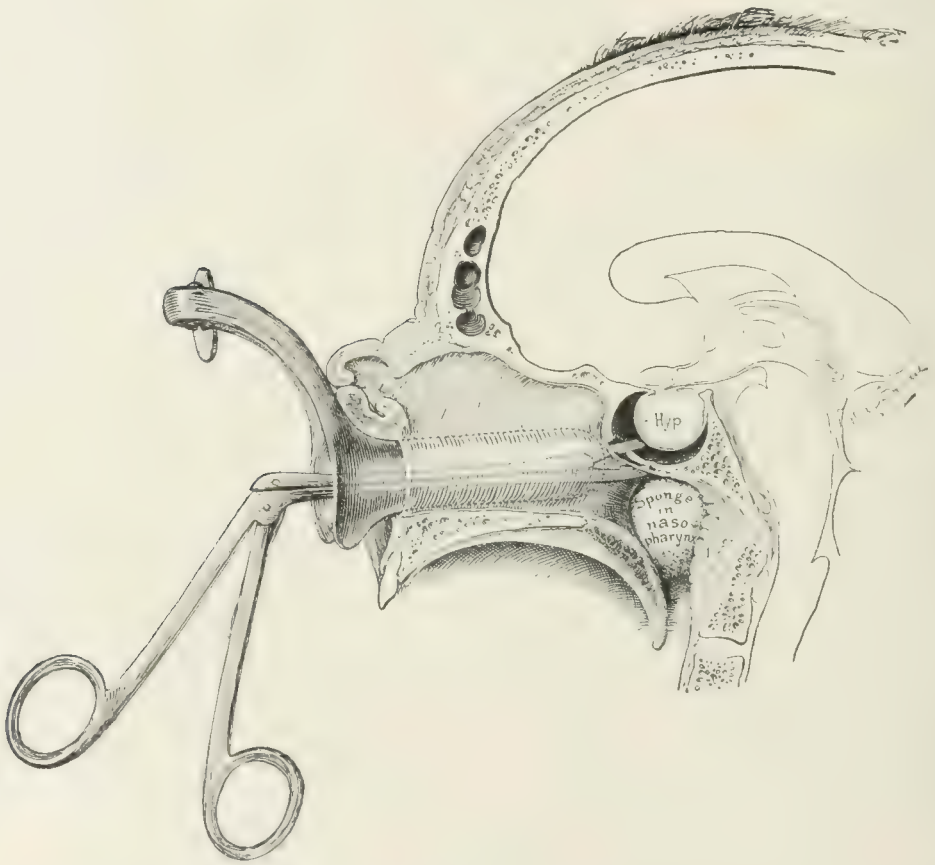


FIG. 551

Lateral diagram to show removal of anterior wall of sphenoidal cells, with nasal rongeurs, of which various types and forms are employed. (The sponge is no longer used.) (Cushing—from Jour. Amer. Med. Ass'n.)

ployed this method with favorable results. The following case will serve as an example.

A twenty-nine-year-old saleslady, following a chloroform anesthesia, eleven years before coming under observation, had, without any other disturbance, ceased to menstruate.

Five years before she had suddenly remarked a duskiness of the

* Centralblatt für Chir., 1912, No. 7.

† Annals of Surgery, Feb., 1913.

face, which lasted about fifteen minutes. From that time on her visual sense began to deteriorate, and for about three years she had not been able to read the paper. In particular she was unable to recognize objects approaching from one side, and as a result she was frightened by passers-by. On the right, vision was somewhat better than on the left. For about three years the sense of smell

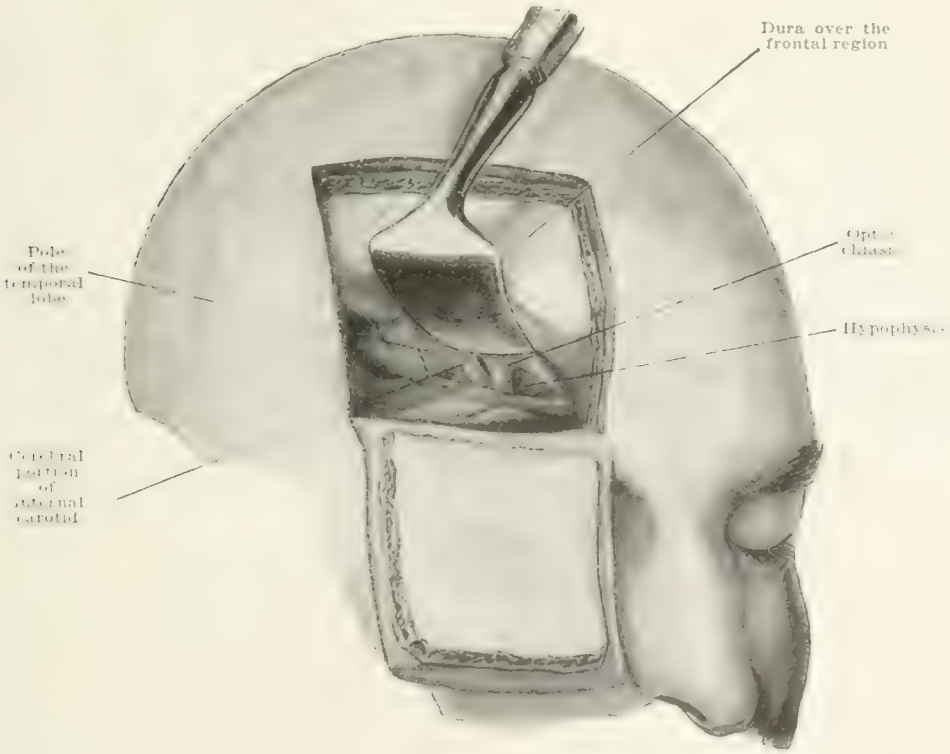


FIG. 552
Fronto-parietal approach to the hypophysis.

had been remarkably poor. At the beginning of the visual disturbance, frequent headaches occurred, particularly in the temporal region, together with vertigo, whenever she flexed the head backward. There was no nausea or vomiting. Neither polydipsia or polyuria occurred.

Since the beginning of her illness the patient had increased considerably in weight, and recently her gloves had become much too small. Not only were her hands remarkably increased in size, but an enlargement could be noticed in the nose, the tongue and the feet. At times macropsia occurred, that is to say, objects appeared

larger than they really were. Recently she had complained a good deal of formication in the legs. Mentally she had deteriorated, though she was never highly gifted, and she began to show an increased desire to sleep.

By the end of February, 1909, Oppenheim had made the diagnosis of hypophyseal tumor. The X-ray showed a considerable enlargement of the sella turcica and this, together with the bi-temporal hemianopsia, the disturbance of smell, the symptoms of acromegaly, and the adiposity, amenorrhea, and headache, substantiated the

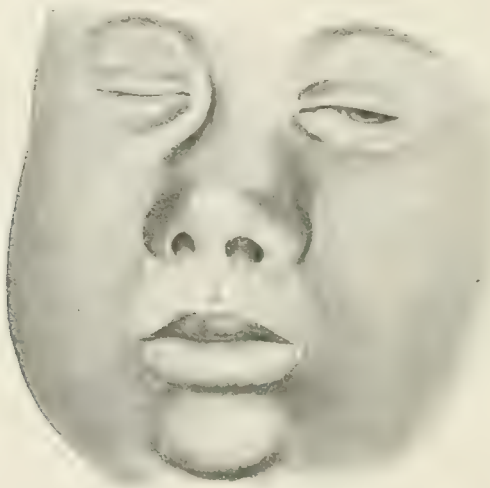


FIG. 553
Acromegalic nose, chin and lips; edematous lids.

diagnosis. The urine was free of albumin and sugar. The disproportionate size of the nose, the tongue and the lips (Fig. 553) as well as of the feet, and particularly the hands, was striking. Subjectively she felt in the best of health.

On March 2, 1909, after a preliminary hemostatic suture, a trap-door was made in the skull over the right temporo-parietal region with the pedicle behind. The edges of the opening measured in front 96, behind 85, above 95, and below 92 millimeters. On March 8, the patient being in good condition and reacting but slightly to the previous operation, the second stage was performed.

The bone flap was turned back and a large dural flap was cut out with its base below (Fig. 554, Plate 93), whereupon two spurting branches of the middle meningeal artery had to be tied with catgut threaded on a needle. When the frontal brain was lifted up

Extirpation of a hypophyseal tumor through the anterior fossa, by the method of F. Krause.

Fig. 554. Exposure of the right temporo-parietal region.

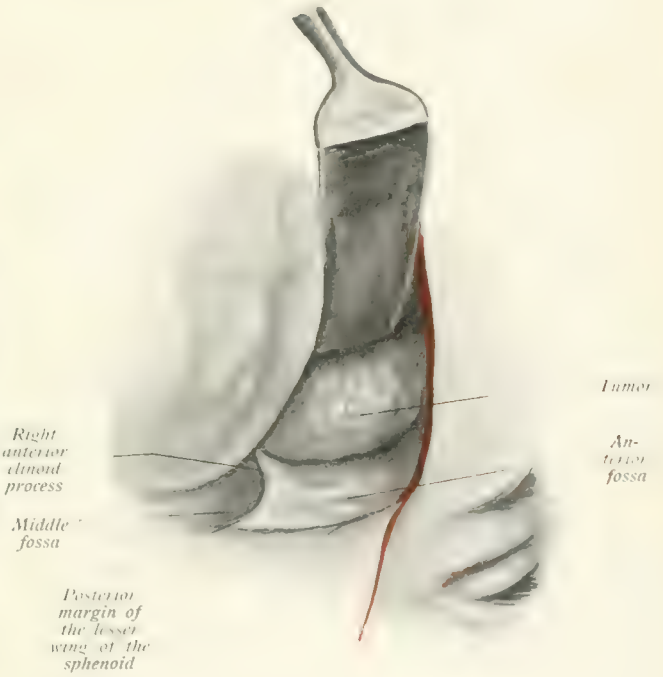


Fig. 555. Exposure of the anterior and middle fossae, right.

Fig. 556. The tumor is freed up with the forefinger.

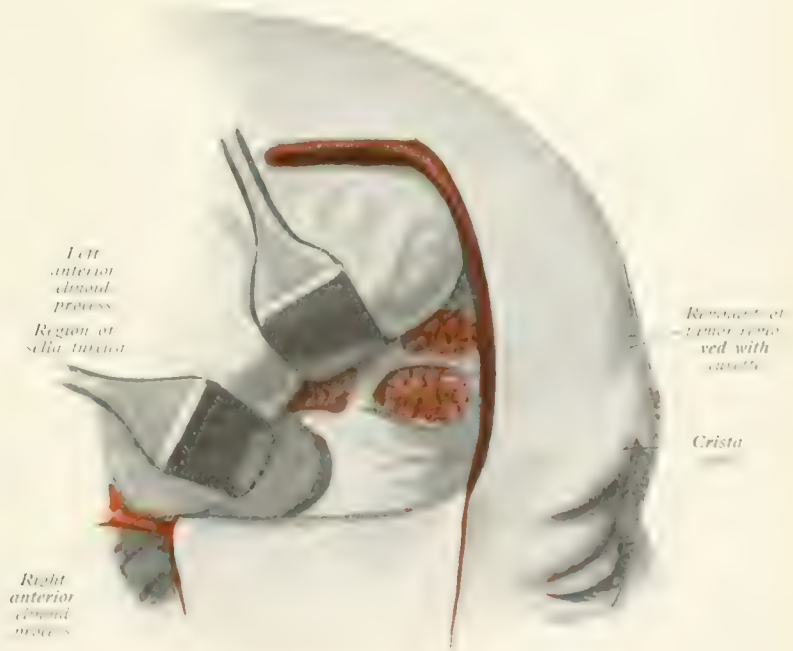


Fig. 557. Beyond the middle line tumor masses remain in places.

on a spatula, we had an unobstructed view, undisturbed by bleeding, of the anterior fossa, the posterior edge of the lesser wing of the sphenoid, together with the sinus which ran over it, and the anterior clinoid process. In addition a portion of the temporal lobe behind the lesser wing of the sphenoid was also visible.

The operation, however, proceeded for the most part in the anterior fossa. Below the right olfactory nerve, a grayish-red mass about the size of a pea came into view, which undoubtedly represented a neoplasm. As the olfactory nerve prevented us from proceeding further, it was torn through with smooth forceps and displaced backward. Now as the frontal brain was lifted still further the tumor developed itself more clearly (Fig. 555, Plate 93). It was seen to be a soft sarcoma, saturated with fluid, of a grayish-red color, and it seemed softer even than the brain substance. After pushing aside the brain by means of sponges held in a forceps or curved clamp, until the tumor was exposed over an area the size of a half dollar, the attempt was made to seize the tumor by weak suction applied through a glass tube which had a diameter of 20 mm. (see p. 532).

The tumor was sucked into a glass, but on account of its great softness, it tore immediately so that this attempt had to be desisted from at once. The tumor was then carefully surrounded by the finger; it extended far beyond the middle line, so that the finger could reach its posterior surface only after it had been introduced to a depth of 8 cm. (Fig. 556, Plate 93). With the finger and a large spoon the tumor was then removed piecemeal.

Thereupon, by carefully lifting the frontal brain, the sella turcica with the dorsum sellæ, as well as the anterior clinoid process of the left side and the eminentiæ capitatæ of the roof of the left orbit could be carefully examined, and finally also the crista galli and the entire ethmoid bone on both sides (Fig. 557, Plate 93). Although the spooning out of the tumor mass was carried as far as possible, on account of its softness and lack of consistency radical removal of the entire mass could not be assured. The hemorrhage was controlled by pressure with sponges, and the dural flap was turned in and the bone flap was sewed back in its original place without packing or drainage. The brain collapsed to a marked degree, for the removal of the tumor left a considerable cavity within the cranium. Correspondingly the dural flap and the skin and bone flap also sank in and formed a deep depression.

The entire tumor, re-formed by putting the various pieces together, consisted of a lobulated mass about the size of a small kidney except that it was thicker, together with two nodes something larger than a walnut which were attached to its forward portion. The total length of the tumor after it had been dried in the air of the operating room was 10 cm., the width of the chief mass 7 cm., and its thickness 4 cm. The surface was smooth and covered with a thin capsule; at one place some brain substance was adherent. The consistency after drying was somewhat firmer than the normal brain substance.

As regards convalescence, the temperature on the day preceding operation was 97.6, and on the evening following operation 101. In the next twelve days the temperature only twice in the evening reached 100.6, but it generally stood about 100.2; in the morning it varied between 98.4 and 99.2. After the thirteenth day it ranged between 98 in the morning and 99.2 at night. The pulse-rate on the morning before the second operation was 96. That night it rose to 128, and with slight variations it remained between 120 and 124 until the twelfth day, when it fell to 112, on the thirteenth day to 104, and then continued to fall until it reached normal.

The wound healed by first intention; there was a slight discharge of cerebro-spinal fluid on the first and second days, so that only the outside of the dressing had to be changed. The entire dressing was renewed for the first time on the fifth day, when some of the sutures were removed, and again on the eighth day, when the remaining sutures were taken out. Hourly injections of camphor and caffein were necessary during the first twenty-four hours on account of severe collapse.

After the operation there arose an almost unquenchable thirst, and on several days the patient took as much as seven quarts of fluid. The urine contained sugar only on the day following operation; later there was no sugar and there was never any albumin. The quantity was six to seven quarts; this began to diminish only after ten days, but for several weeks the patient continued to secrete about three quarts. She was very restless during the first few days, talked a good deal and tried to get out of bed, but her sensorium was clear. On the third day, as a sequel of the operation, a paresis appeared in the left side of the face and the left arm, which in the course of a week gradually became a complete paralysis and passed over into the left leg. The affected limbs

were hyperesthetic. The reflexes on the paralyzed side were increased and the Babinski and the Oppenheim phenomena were present, as well as hand clonus.

The patient at times showed a high degree of somnolence; she talked like a person who was dazed from lack of sleep. By the twenty-fourth of March, the lower part of the nose was thinner and clear. In four days more it appeared much less swollen and thickened than before the operation. Also the hands, particularly the right, had become thinner. But it was rather surprising that the lips remained thickened. By April 10 the nose appeared normal.

In the later course of the disease conditions of excitement occasionally arose, and the patient, having formerly been quiet, became very irritable. The facial paresis disappeared within the space of seven weeks and the paralysis of the left arm and leg became slowly better at the same time. By the beginning of April, she was able to count fingers with the right eye at a distance of 1 meter.

The patient in April was mentally normal. She talked a good deal and still complained of her thirst. This condition remained unchanged for the following months. On February 12, 1910, she was discharged from the Augusta Hospital without being able to stand or to walk on account of the marked paresis of the leg. The bony plate at the time of discharge projected slightly and gave the sense of fluctuation. The patient remained in bed for another six months and then she would sit up for hours at a time in a reclining chair almost every day. After December she got up every day and walked about some with assistance, and the paralysis had improved. Her appetite was abnormally large, so that she apparently could not be satisfied. She showed for the most part a happy and hopeful disposition. She had menstruated twice.

Of the further course of the disease we received no information until January 1, 1913, when, to our surprise, we received a letter nicely written by the patient herself, in which she informed us of her satisfactory condition, good appetite and good digestion. Menstruation had been regular for a year. Since September, 1911, she had been able to go about alone, and with a little difficulty could use the left hand passably well.

By request she visited the hospital in January, and we found the following conditions: the acromegalic changes of the hands, lips, and lids had disappeared, as was also true of the legs and feet. Since the operation a few beard-like hairs had grown on the upper

lip and cheek. Of the cerebral nerves only the olfactory and the optic were affected; the sense of smell was diminished markedly on both sides, on the left more than the right. There was optic atrophy on both sides with narrowing of the vessels, but the manifestations of congestion had disappeared. On the right side Snellen test type 1.25 could be read at 25 cm. and the visual acuteness for distance was 6/25; on the left side fingers could be counted

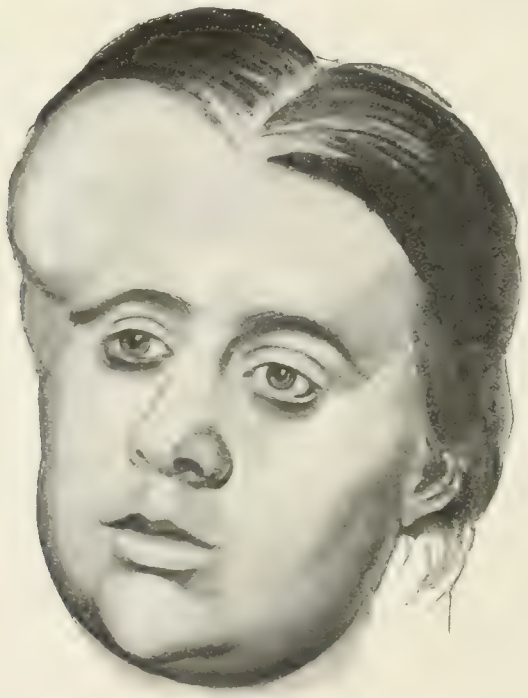


FIG. 558
Cerebral hernia, with external hydrocephalus.

at 2½ meters. The visual fields were concentrically diminished, and still more strongly for colors; but the hemianopsia had disappeared. The sense of taste had deteriorated. Speech was unimpaired and the intelligence was excellent. The early forgetfulness had disappeared; the patient was happy, without exhibiting any clownish tendencies. A twenty-four hour quantity of urine varied from 1½ to 2½ quarts; it showed neither albumin nor sugar.

On the left the arm and hand were only slightly weaker than on the right; all movements were carried out well. The sensibility and stereognosis were preserved, and no pathological reflexes were present. The patient went about alone. The strength of the left

Drainage of a postoperative hydrocephalus externus by means of vein-implantation after the method of Payr.

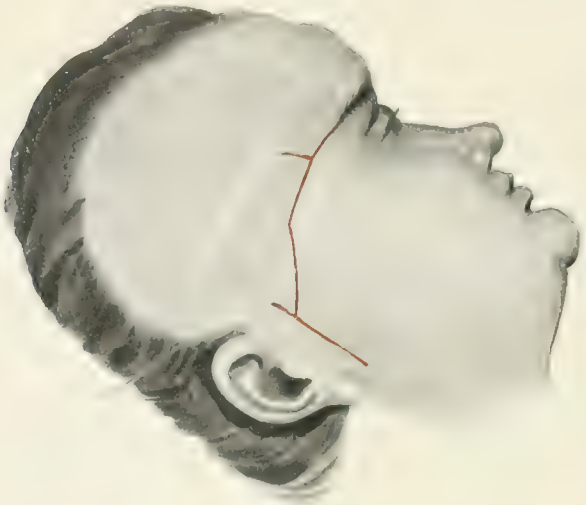


Fig. 559. Incision

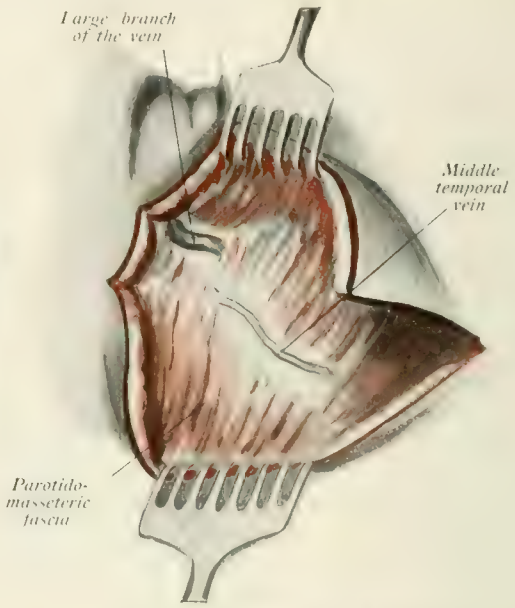


Fig. 560. Dissection of the veins.

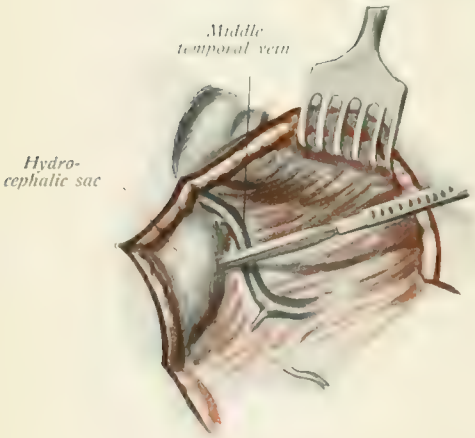


Fig. 561. Opening of the hydrocephalic sac

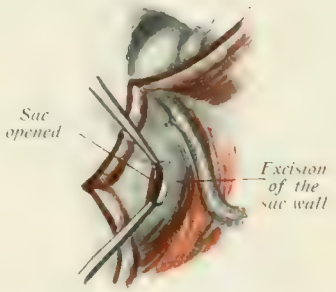


Fig. 562. Crescentic excision of the sac wall.

Fig. 563. Oblique division of the vein to be implanted.

Fig. 564, 565.
Fixation of the lumen of the vein by two holding sutures.

Fig. 566. Medial suture completed; lateral row of stitches in place.

Fig. 568. Condition after completion of skin suture.

Fig. 567. Implantation of vein completed; a small opening in the sac wall which remains is sewed up.

leg was not less than that of the right, but the left leg got tired sooner, and she dragged it somewhat in walking. The same manifestation of easy tiring appeared in the left hand on working. In the leg also there was no disturbances of sensation or any pathological reflexes, and there was no ataxia in either arm or leg.

The circumference of the head was 65 cm. The entire operative area in the frontal region of the forehead projected like a hernia to the height of 3 cm. This hernia measured from before backward 16 cm., and from above downward 11 cm. The large bony plate had been pushed downward somewhat, and its lower margin was in contact with the edge of the osteoplastic opening. On this point, as a hinge, it could be pushed in somewhat against the brain, but it sprang immediately back. At the upper anterior and lower margins the hernia-like protuberance was very wide and was covered with a normal pale and easily movable skin, which showed scars only corresponding to the operative wound. The entire hernia felt tense. Nowhere could any resistance or hard places be felt which might justify the suspicion of a recurrence. Even strong pressure on the hernia was only mildly painful. The protuberance was evidently caused by a collection of fluid.

DRAINAGE OF EXTERNAL HYDROCEPHALUS BY VEIN IMPLANTATION ACCORDING TO THE METHOD OF PAYR

As the patient was troubled a great deal by her condition, and at times experienced severe stretching pains and also laid a good deal of weight on her appearance, we performed a modification of the Payr operation on January 25, 1913. We undertook, by implanting into the sac a facial vein of sufficient size, to establish permanent drainage into the right jugular system. In this connection it was important to notice that the cerebral hernia did not pulsate and was not under tension, but appeared moderately soft. The internal pressure, accordingly, was not considerable, and this fact, under certain circumstances, would have properly rendered our attempt at venous drainage ineffective. But theoretically this could not be determined, the only way to find out was to try it.

As compression on the neck did not cause any definite system of veins to stand out sufficiently in the neighborhood of the sac so that incision could be made directly down onto them, the middle temporal vein was exposed just in front of the ear by an oblique incision, and dissected out (Fig. 559, Plate 94). From this point

the vein was followed forward and upward to the outer corner of the eye. In this dissection a large vein came into view in the neighborhood of the eyebrow, apparently a branch of the middle temporal vein. It was striking that this branch, which lay peripherally, was considerably larger than the main trunk in front of the ear. These veins lay in the deep layer of the subcutaneous fat above the fascia, and by lifting up the skin with rake retractors under considerable tension, they came into view and could be freely exposed (Fig. 560, Plate 94). The large vein (supraorbital) was followed in the direction of the eyebrow in order to free up a portion of sufficient length for implantation into the sac. In this region two lateral veins bled and had to be tied off. In dissecting out the vein the hernial sac came into view (Fig. 561, Plate 94).

The veins were freed up from the underlying layer close to the periosteum for about 2 cm., but they were not entirely freed of the surrounding connective tissue and fat. They were divided obliquely in order to give a sufficiently large lumen for implantation. The connection with the sac of the cyst must be made as near as possible in its most dependent portion, in order that, as the sac collapses, the lumen may not be obstructed by a fold, acting like a valve. The drainage opening should also be situated near the place where the sac borders on the bony base of the skull. After the sac was opened obliquely for a scant centimeter, a crescentic strip was cut out from the lower margin in order to create a sufficiently large opening (Fig. 562, Plate 94). All the tissue covering the sac in the immediate neighborhood of the incision was cut away, in order to leave for suture to the vein a thin membrane corresponding to its proper wall.

The vein was now tied at the farthest point to which it had been freed and was divided proximal to the ligature (Fig. 563, Plate 94). The end was then cut obliquely by fine scissors in order to give a larger lumen to facilitate the suture. There was no fear that the blood might run backward into the sac by a reversal of the flow in the vein, as the direction of the vein was hardly disturbed and the valves prevented back flow. After division one small drop of blood came out of the vein. During the suture the vein was compressed centrally by the finger of an assistant, and at the same time the sac was compressed by the hand in order to prevent the entrance of air.

The finest needle and paraffin silk were used for the suture.

First the sac was penetrated by the needle from without inward, so that the intima of the sac was securely seized in the suture. Then the needle was passed from the lumen of the vein outward through its entire wall. Two holding sutures were placed half way around the vein at a distance of about two millimeters from each other (Figs. 564 and 565, Plate 94).

On the whole five more interrupted sutures sufficed to unite the obliquely divided lumen of the vein in the typical manner to the sac of the cyst (Fig. 566, Plate 94). A small portion of the opening in the cyst which still remained open was closed with one stitch of paraffin silk. Thereupon light pressure on the sac showed that the fluid which was still present ran into the vein, demonstrating the good functional efficiency of the anastomosis. The skin wound was sewed up (Fig. 567, Plate 94) and a light compression dressing applied; the skin wound was somewhat zigzag, because it had to follow the course of the vein. After a large quantity of clear fluid had flowed out, the sac appeared flaccid and the skin on the forehead over it lay in folds. In the flaccid sac nothing hard or resistant could be felt, nor was there any sign of recurrence of the tumor.

If we could have foreseen that so large a deep vein followed the upper margin of the orbit, the first perpendicular incision in front of the ear could have been omitted, and only the obliquely horizontal incision running to the eyebrow would have been necessary. Healing was uneventful. The temperature rose only once, on the fourth evening, to 99.8, and the pulse on the second evening to 108, but otherwise the chart was normal. As there was no leakage of fluid the dressing was first changed on the ninth day and showed the wound healed. The patient was discharged twenty days after the operation. The sac had remained entirely soft and hardly bulged above the level of the forehead, so that it could be hidden by combing the hair over it. The intense pain had disappeared and the patient left the hospital comparatively happy.

The question arises whether the same result could not have been obtained by repeated puncture. According to our experience with a cyst which existed for several years and the wall of which showed no tendency to absorption, this is not open to question. Excision of the entire sac, which promised cure, would have been a serious operation and, moreover, could hardly have been carried out with

assurance since, according to the finding at the previous operation, it must have been extended far into the middle fossa.

According to the Payr method of drainage of internal hydrocephalus, a drainage-tube must be introduced into the depths of the lateral ventricle. For this purpose there is employed an artery which has been dissected from a calf, which is covered with the saphenous vein of the patient. But in our case, the modification which was described was possible, because it was a case of a subfascially situated hydrocephalus externus.

TEMPORAL APPROACH TO THE HYPOPHYSIS

Caton and Paul have described a temporal approach to the hypophysis; for this purpose a flap similar to that for extirpating the Gasserian ganglion is necessary. Horsley has carried out several such operations and he proceeds to the hypophysis by lifting up the temporal lobe with the brain spatula after opening the dura. In this approach the S-shaped curve of the carotid artery forms an obstruction and must be carefully looked out for.

W. Braun has shown by investigations on the cadaver that one can reach the sella turcica and the hypophysis also extra-durally through an osteoplastic opening made in the temporal region, that is to say, beneath the cavernous sinus. This technique, however, has a very limited applicability.

For the sake of completeness, other methods should be mentioned. Friedmann and Maas have been able in cats to extirpate the hypophysis after dividing the soft palate and trephining the body of the sphenoid exactly in the middle line. Fritz König has tried the same technique on the cadaver of adults. Against the employment of this method in man, there should be mentioned the danger of septic infection and the limited oversight allowed by the small operative field; the hypophysis is surrounded by large blood vessels.

SURGERY OF THE POSTERIOR FOSSA

The posterior fossa is contained largely in the occipital bone. On the floor lies the foramen magnum. The anterior wall is formed by the basilar portion of the occipital bone, and the posterior wall by the inferior occipital fossa. This extends upward as far as the transverse sulcus, which corresponds to the level of the external occipital protuberance. The lateral walls of the posterior fossa,

which run obliquely forward and inward, are made up of the posterior surface of the petrous portion of the temporal bone, and its roof is represented by the tensely stretched tentorium cerebelli which lies between the occipital lobe and the cerebellum.

In this space, bounded in front, on each side, behind and in large measure below also by bone, and which is shut off above by a tense membrane, there lie crowded close together the nerve structures which unite in themselves practically all the nerve tracts which are significant in the carrying out of the bodily activities. On the basilar portion rest the medulla oblongata, the pons, and a portion of the cerebral peduncles. The triangular-shaped portion which is left contains the cerebellum, that overhangs the pons and the medulla like a tent roof. In front facing the middle fossa and above the cerebral peduncles lie the corpora quadrigemina.

All these cerebral masses surround and include a common space which from the foramen magnum on is called the fourth ventricle, and which further forward becomes the aqueduct of Sylvius. The roof of the fourth ventricle is formed by the anterior and posterior medullary velum, upon which are situated respectively the superior and inferior portions of the vermis of the cerebellum. The lateral wall of the fourth ventricle is composed of the three pairs of cerebellar peduncles, the first, the brachia conjunctiva or crura cerebelli ad cerebrum, runs to the corpora quadrigemina; the second, the crura cerebelli ad pontem, goes over into the pons; and the third, the restiform bodies or crura cerebelli ad medullam oblongatam, runs to the medulla oblongata.

In addition there lie in the posterior fossa the points of entrance or exit of the last ten cerebral nerves, their nuclei, or at least portions of the nerves.

The pons contains, simply speaking, all the motor and sensory tracks which run between the brain and the spinal cord. In the corpora quadrigemina lie the nuclei of the nerves which have to do with the movements of the eye, and for the auditory nerve of the opposite side. Caudally on the floor of the fourth ventricle are located the nuclei of the other cerebral nerves from the oculo-motor to the hypoglossus, as well as the nuclei for the vestibular nerve, which is stimulated by changes in position of the head and trunk, as well as the nerve elements of the vagus, together with the still hypothetic respiratory center.

Just above the anterior boundary of the foramen magnum the

vertebral arteries on both sides penetrate the dura mater and unite on the inferior surface of the medulla oblongata to form the basilar artery, which gives off at practically right angles numerous branches to supply adjacent portions of the brain. Finally, there is contained also in the posterior fossa the transverse or lateral sinus, which collects the greater portion of the blood from the cranial cavity. The left sinus, as a rule, is situated somewhat deeper than the right. Laterally and in front it runs into the sigmoid groove (this portion is sometimes called the sigmoid sinus), and then empties its contents into the internal jugular vein. From the torcular Herophili (confluens sinuum), which is the point of junction of the longitudinal sinus with the lateral and straight sinuses, there runs downward in the narrow falx cerebelli the occipital sinus; it divides below, embraces the posterior half of the foramen magnum and opens on both sides in the jugular foramen with the lateral sinus into the internal jugular vein.

SYMPTOMATOLOGY

The manifestations resulting from tumors, cysts and other processes which diminish the space in the posterior fossa may be divided into three main groups: the results of generally increased intracranial pressure (headache, vomiting, choked disc, vertigo, pressure pulse, and stupefaction), the effects of local compression, and the influence upon neighboring nerves and portions of the brain.

Among the local manifestations the cerebellar or vestibular vertigo, a subjective sensation of a rotation, either of the body itself or of everything outside, is the most important. Ziehen has described under the term "vestibular attacks" cases of rotatory vertigo in conjunction with other disturbances of coordination such as nystagmus, double vision, vomiting, and severe headache.

A second symptom, ataxia, expresses itself in walking, sometimes in the use of the upper extremities, and also in the motion of sitting down and standing up. The cerebellar ataxic gait resembles the staggering of a drunken person. Adiadochokinesis, by which is meant the loss of ability to carry out movements and contra-movements in rapid succession, for instance repeated pronation and supination of the forearm, shaking of the hand, piano-playing movements of the fingers, flexion and extension of the elbow and in the ankle joints, represents a hemi-ataxic disturbance. These movements take place awkwardly and with considerable trouble

upon the side corresponding to the location of the tumor, while the arm and hand of the normal side retain the dexterity which they have acquired.

In addition of the many ataxic manifestations, pure motor disturbances are occasionally observed, very infrequently unilateral flaccid paralysis, more frequently spastic paralysis of the opposite extremities, and also, according to Oppenheim, forced movements and forced maintenance of position. Epileptiform convulsions in affections of the cerebellum are exceptional.

Of sensory disturbances, tabetic ataxia and disturbances in the sense of position are observed if the pressure is exceptionally great upon the pyramids. The pyramidal tracts suffer particular injury in foci in the pons. In such cases spastic paresis, sensory paralysis with astereognosis and disturbances in the sense of position can be demonstrated on the opposite side of the body.

The participation of the cerebral nerves is expressed by bulbar manifestations, by disturbances on the part of the nerves which control the movements of the eye, in nystagmus or in paralysis or weakening of the abducens nerve, as well as by disturbances of the auditory and facial nerves, and finally by paretic manifestations on the part of the glosso-pharyngeal, spinal accessory and hypoglossal nerves. The motor branches of the vagus may likewise be sympathetically involved.

Lesions of the vestibular nerve cause, as a rule, the same ataxic disturbances as injuries of the cerebellum. The vestibular ataxia expresses itself by staggering or unsteady gait and in other disturbances of motility, and it is subjectively experienced as a rotatory vertigo. Bárány has introduced a simple method for distinguishing the two. He allows cool water to trickle onto the drum membrane. As a result of the cooling, a current is set up in the endolymph and causes an irritation of the vestibular nerve. If the vestibular apparatus is intact, there follows the so-called caloric nystagmus.

Among the disturbances of the other cerebral nerves the beginning of a paralysis of the trifacial seems to be the most important and the one which is least likely to be absent. According to Oppenheim, it manifests itself in its first stages as a reflex anesthesia of the cornea, in the great majority of observations on the side corresponding to the tumor. In case amaurosis has occurred, no particular weight can be placed upon the reflex anesthesia. Moreover,

Oppenheim has called attention to the fact that an anesthesia, or at least a distinct loss in reflex irritability of the cornea, can be demonstrated in many cases if the patient changes his position. Otherwise, there are found conditions of irritation or of paralysis in the trifacial, for instance paresthesia in the cheek or in one-half of the tongue. In other cases a true trifacial neuralgia occurs. Paralysis of the muscles of mastication is seldom observed. In extirpation of tumors at the cerebello-pontine angle neuroparalytic keratitis may occur (see Vol. I, p. 244).

OPENING THE POSTERIOR FOSSA: POSTURE

Our custom, in cerebellar operations, is to place the patient in a sitting posture. The head and shoulders project beyond the back support so that one can approach comfortably to the region above the external occipital protuberance. The assistant who holds the head from in front must rotate it as directed by the operator, flex it to one side, or bend it forward. Some operators prefer to have the patient lie face downward upon a table, and for this purpose make use of a frame such as that described on page 465, which supports the patient by shoulders and forehead, without impeding respiration. The anesthesia is carried out from below, and does not interfere with the operation.

The anesthetist should be provided with an assistant to observe the pulse and respiration rate, and the blood-pressure, which should be charted at frequent intervals. Not infrequently we have to proceed as far as the medulla oblongata and into the immediate neighborhood of the cardiac and respiratory centers, and repeatedly the operation has to be interrupted while the breathing and the cardiac activity can be restored. Some adequate apparatus for instituting and maintaining artificial respiration should always be at hand; if intratracheal etherization is being used, the apparatus can immediately be converted to this purpose. Needless to say, only an expert anesthetist should be employed.

In exposing both hemispheres, care is taken, if the patient is upright, that the head be not bent backward too far, so that the cerebellum will fall back strongly and create a pull on the medulla. This falling backward, however, is necessary if one wishes to expose the superior portion of the vermis in the depths, or to precede as far as the corpora quadrigemina.

Exceptionally it is advisable to lay the patient flat upon the side

in such manner that the shoulder lies at the edge of the table and the head and neck are freely approachable. The head is then held by an assistant, or better still by a head support such as we use in many cases of operations upon the spinal cord. This technique is not to be recommended; however, in many cases tumors of the auditory nerve may satisfactorily be removed in the lateral posture.

After the operation the head is held toward the operated side so that pressure of the blood, which oozes up from the bed of the

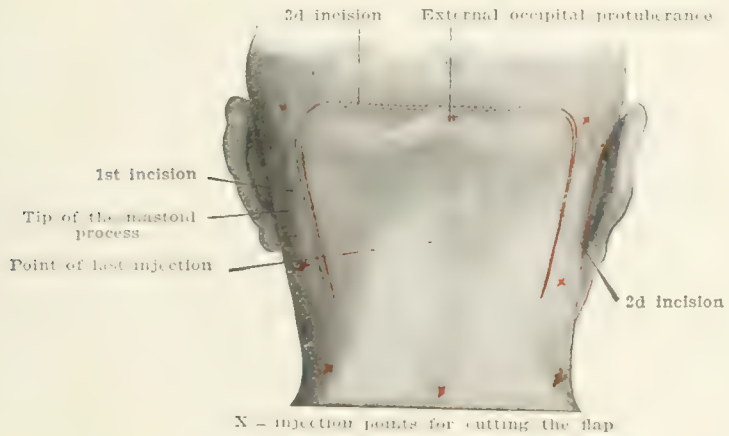


FIG. 569

Method of injecting for exposing both cerebellar hemispheres under local anesthesia.

tumor, on the medulla oblongata and the pons, will, as far as possible, be avoided.

EXPOSURE OF BOTH CEREBELLAR HEMISPHERES: LOCAL ANESTHESIA

In regard to local anesthesia, we shall give here a few special directions in addition to what has already been said in Vol. I (p. 30 ff). Scopolamin should in general be avoided in brain operations, because the sleepiness which this agent induces, in conjunction with the somnolence caused by the brain tumor, represents an added element of danger.

In order to expose both cerebellar hemispheres under local anesthesia in a man thirty-four years old, we proceeded as follows (Fig. 569). The external occipital protuberance was marked with the tip of the knife. The first injection of 2 c.c. was made sub-

cutaneously at this point, the second and third injections, in like quantity, were made at the same level to the right and left at the posterior margin of the mastoid process. The fourth and fifth injections were made on each side two finger breadths below the tip of the mastoid process, at the posterior margin of the sterno-mastoid muscle, the sixth and seventh injections at the anterior margin of the insertion of the trapezius at about the level of the fifth and sixth cervical spines, and finally the eighth injection was made in the middle line just over the sixth spinous process. From these points the entire area was injected subcutaneously by withdrawing the needle and introducing it again radially in all directions, in order to limit hemorrhage so far as possible. The quantity of solution used is unimportant.

The most important injection is that at the lower margin of the mastoid process on each side. From this point the injection is made subfascially and intramuscularly, and the needle is finally introduced so far as possible and in different directions, at least 10 c.c. being injected on each side, so that the occipital artery as well as the major occipital nerve is circuminjected at this point. There then follows the injection of the muscles of the posterior neck in layers, through their entire thickness, from the three lower injection points. And finally still another injection may be made in the middle line at the point shown in the cut.

In all 100 c.c. of one-half per cent. novocain solution with 15 drops of 1-1000 suprarenin solution were injected in this case. Since this procedure is really a conduction anesthesia, one must wait at least ten minutes after the injection is finished. Subperiosteal injections are never carried out (see Vol. I, pp. 39 and 41). The patient experienced, during the entire operation, no sign of pain, except for one moment which we will speak of later.

CONTROL OF HEMORRHAGE

If the local anesthesia is properly carried out, the Heidenhain hemostatic suture is unnecessary; but often it can be dispensed with in exposure of the posterior fossa under general anesthesia, if one begins the operation by tying both occipital arteries. After these are excluded the bleeding is usually minimal. In our case the entire left half of the cerebellum and the larger portion of the right half had to be exposed.

In the first place a longitudinal incision was made on the left

Exposure of both posterior fossae.

Fig. 571. Dissection of the left occipital vessels.

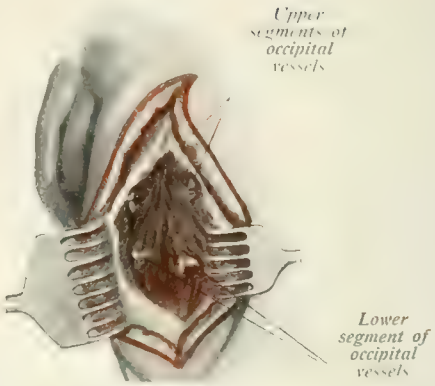


Fig. 572. Occipital vessels on the left are double tied and divided.

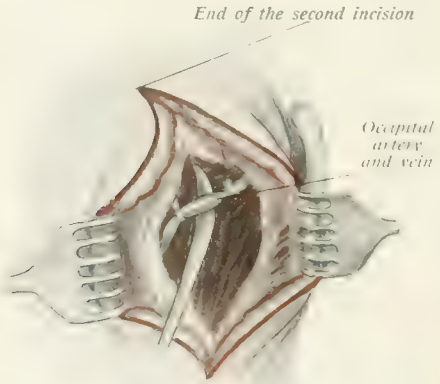


Fig. 573. Exposure of the right occipital vessels.

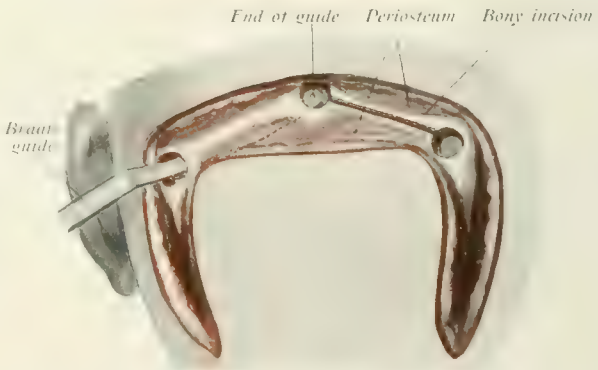


Fig. 574. Three drill holes made; on the left the dura is being separated, on the right bony incision completed.

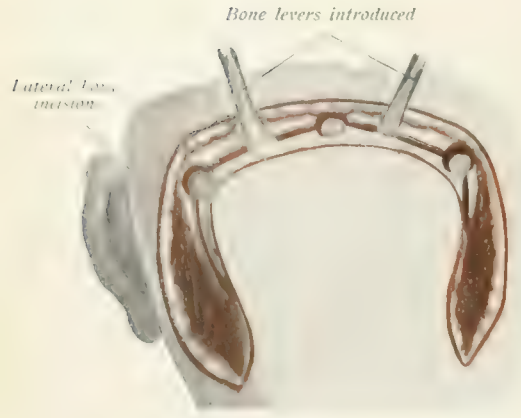


Fig. 575. Prying up the bone plate.

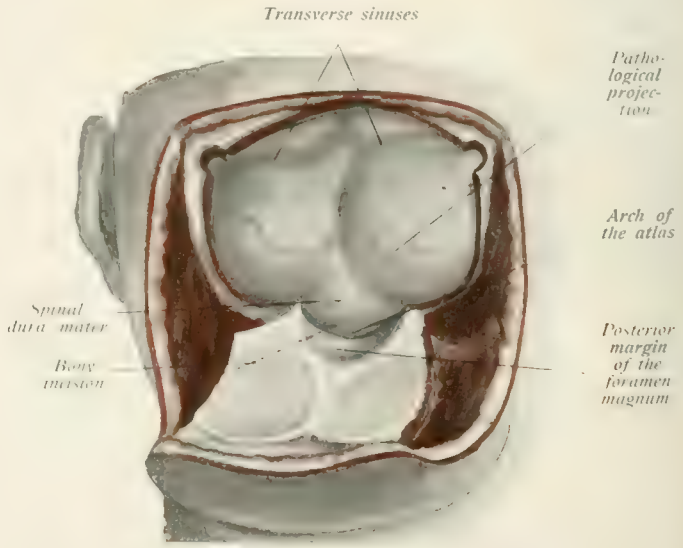


Fig. 576. Cerebellar fossae of occipital bone turned down.

side near the posterior margin of the mastoid process (Fig. 569). Above the incision curved outward somewhat, so as to give plenty of room. Skin, subcutaneous fat, fascia, and below some of the muscle, were divided until we reached the occipital artery, which was exposed by cutting some of the tissues above and below in a horizontal direction (Fig. 571, Plate 95). The artery had a slight obliquity inward and upward. It was double-tied and divided.

At this point the vessel bundle lay a finger's breadth above the tip of the mastoid process and near its posterior margin. As the incision was deepened, an artery came into view again 1 cm. below the point of ligation; here it ran obliquely outward and upward. Evidently it was simply the proximal portion of the same artery; it was likewise double-tied and divided (Fig. 572, Plate 95). In this way the hemorrhage was controlled, and only in the lower end of the incision, which extended deeply into the cervical muscles, did one good-sized vessel have to be tied. The incision was thereupon carried down to bone.

On the right side the occipital artery ran more superficially (Fig. 573, Plate 95). The vessel bundle was freed up with a blunt dissector, double-tied and divided. After excluding the occipital artery the incision was then carried down to bone. In the deep muscular layer, close to bone, another vessel had to be tied off with catgut on a needle, and in the lower portion of the incision, just as upon the other side, a spurting artery was tied. Parenchymatous bleeding was exceptionally slight and ceased on short compression.

Ligation is indicated on both sides, since the course of the occipital vessels, as in this case, exhibits many variations.

MAKING THE TRAPDOOR

After both occipital arteries were taken care of, the upper ends of the vertical incision were connected by a transverse incision running above the external occipital protuberance, which was carried immediately down to bone (Fig. 574, Plate 95). This incision should run above or at least at the level of a line corresponding to the transverse portion of the lateral sinus, that is to say above the external occipital protuberance. At the upper margin of the incision three arteries had to be tied off on a needle, because the tissue being tense, a ligature would be likely to slip. Three drill holes were then made, one at each upper corner of the flap and a

third in the middle line just above the external occipital protuberance. Two drill holes, one at each upper corner of the wound, may suffice for a complete exposure of the cerebellar hemisphere. The bony incision is then started from these two corner holes and carried toward the middle line, until they meet.

In our case the dura was freed up from the skull through the right drill hole with the Braatz separator as far as the middle drill hole, and the bone was then divided with Dahlgren forceps; this occasioned the first slight complaint on the part of the patient. Then the dura was freed to the middle line from the left drill hole, because the separator could only be introduced with difficulty through the middle drill hole on account of the thickness of the occipital crest; but the bone was divided from the middle line toward the left side. If the bone in the neighborhood of the occipital crest is too dense and thick for the Dahlgren forceps to readily seize and cut it, it is a good plan to cut a channel halfway through the bone with a gouge.

The dura was then freed up, first through the right and then from the left drill hole downward, and the bone divided. In this case no emissary veins of Santorini were visible. Both lateral bony incisions were carried down as far as possible. In this procedure it must be observed that the further downward one goes on the cranium the more horizontal it becomes, and the Dahlgren forceps must be held correspondingly.

Two elevators were then introduced into the upper bony incision and the bony plate pried up for about 1 cm. (Fig. 575, Plate 95). This caused the posterior circumference of the foramen magnum to break. Before breaking down the trap door it is necessary that the two lateral incisions in the soft parts be extended sufficiently far down the neck. If a hemostatic suture has already been introduced in such a way as to limit the length of the incision, the incisions are continued as far as necessary by cutting directly across the hemostatic suture; the length of the incision is the more important of the two.

The modified Langenbeck forceps (see Fig. 493, Plate 82) were then applied from above along the internal occipital crest, as far downward as the foramen magnum, and the bony plate turned backward. This must be accomplished under even pressure, applied in such a way as not to twist the bony fragment, in order that the two bony points which project alongside the foramen magnum may

not be allowed to exert a dangerous pressure upon the medulla oblongata (Fig. 576, Plate 95). Twisting of the bony plate must be carefully avoided, and it is for this purpose that the long lateral incisions are necessary.

In examining the inner surface of the bony plate it was found that, as is ordinarily the case, the posterior half of the circumference of the foramen magnum was broken away. In the innermost depths of the wound the posterior arch of the atlas could be seen and palpated. The sharp processes of bone which represented the sides of the foramen magnum were trimmed off with rongeurs, so that they might not project into the lower aspect of the brain as the result of pressure on the bony plate. If the internal occipital crest projects markedly, it may be of advantage also to bite this off flat with rongeurs in order to create an even bony surface. If the lateral bony incision has not been carried down far enough, the bony plate may break off above the foramen magnum. In that case one must trim away with rongeurs the margin of the base of the skull which remains, in order to obtain free approach to the cerebellar hemisphere.

In turning back the bony plate in the left lower region the marginal sinus was torn close to the arch of the atlas. Hemorrhage was very strong, but it could be immediately controlled by pressure with the finger until a small strip was packed against it; this had to be left in for four days. Above at the torcular (confluens sinuum) a small emissary bled mildly, and this hemorrhage likewise was controlled by a strip of gauze. The ends of the two strips were passed out through corresponding openings in the suture line. After tying the visible vessels, deeply placed catgut sutures united the thick musculature on the two sides. The bony plate was turned up and the skin was sutured with interrupted silk, except for the exit of the packing, with the head extended backward in order to relieve the tension of the deep cervical muscles.

In this case the opening in the skull measured from left to right 9 cm., from above downward 8 cm. Above the transverse portion of the lateral sinus and the torcular (confluens sinuum) were exposed. In order to render the sigmoid portion also visible, the incision must be lengthened laterally on the affected side, the periosteum and the oblique origin of the sterno-mastoid must be freed up from the mastoid process, and the necessary bone must be removed from this with rongeurs. In this case one emissary vein

is ordinarily exposed, and the hemorrhage from this must be controlled by ligature or packing.

In very infrequent cases we have seen strong hemorrhage take place at each cut from emissary veins at the upper margin of the bony flap. Ordinarily in such event the hemorrhage may be controlled by hammering with a Passow chisel or by stuffing a bit of muscle into the hole (see p. 479). But if the hole in the bone is too wide, a strip of gauze must be packed in. Then one can continue the flap formation in the ordinary manner with preservation of the bone. This is to be striven for in the first stage of a two-stage operation, because cutting out the flap with the Dahlgren forceps is a simple procedure and ordinarily may be carried out without hemorrhage of any account, and, moreover, there is less trauma and vibration in cutting through the bone than if it is broken away piece by piece with rongeurs. This last technique, however, may become necessary in cerebellar operations, as was recently the case, for instance, in a thirteen-year-old girl in whom a strong emissary hemorrhage was met with from every periosteal incision and drill hole, and the loss of blood accordingly was too great to allow of preservation of the bone. If the dura is once exposed, all sinus and emissary hemorrhage may readily be controlled by gauze compression.

In the second stage, after the tumor has been extirpated, the bony plate, which till then has been preserved, may be sacrificed in all cases in which it cannot be brought readily into approximation with the upper bony margin by periosteal or bone suture. This is what ordinarily occurs in tumor operations. The thick musculature over the occipital region, generally speaking, forms a sufficient protection. If, on the other hand, the intracranial pressure is not increased, or if the increase is slight as in the case of a serous meningitis, the preservation and suture of the bony plate completely restores normal conditions. The advantage of removal of the bone at the second stage is that it leaves a fresh wound surface which immediately adheres to the dura. The bony plate is removed by blunt dissection from the periosteal layer. The scissors are necessarily only at the tendinous insertions; hemorrhage is ordinarily very slight.

Some surgeons have discarded the osteoplastic flap entirely in operations for sub-tentorial lesions. Cushing's incision, pictured in Fig. 570, resembles a cross-bow; the transverse limb follows the

occipital ridge, and the vertical runs down to the median line to the spinous processes of the upper cervical vertebræ. At the upper edge a fringe of muscle and aponeurosis is preserved, and to this the muscle flaps are sutured in closing the wound. After the bone is bared, he makes a primary opening on either side, and starting

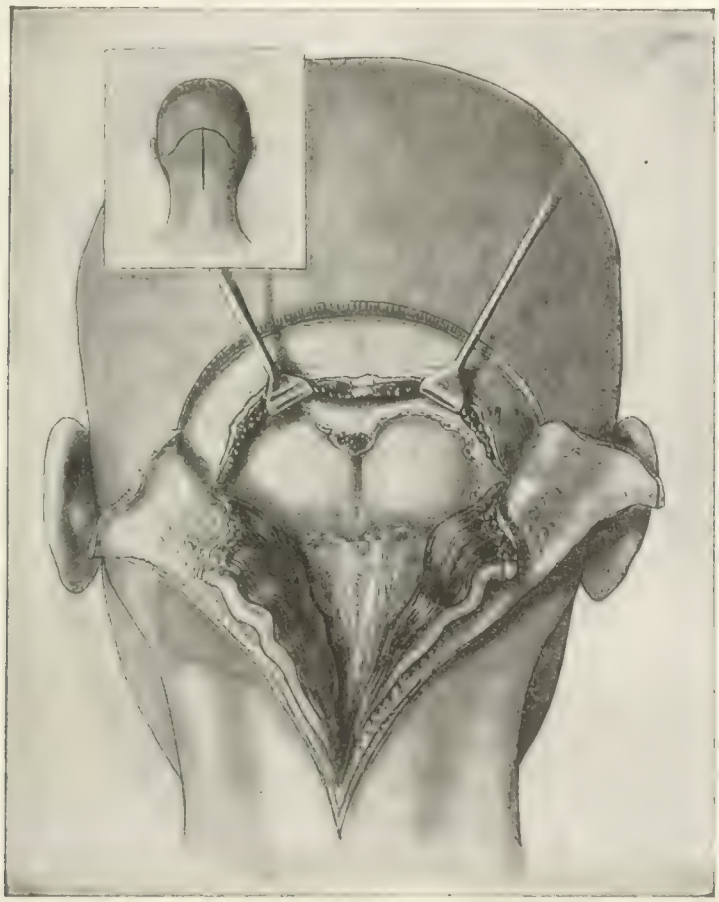


FIG. 570

Cushing's "cross-bow" incision, bony opening partly made. Note fringe of muscle and fascia left above for subsequent suture to reflected muscle flap. (Cushing—from Keen's Surgery.)

from these, rongeurs away the bone, upward to expose the lateral sinus (but leaving the bone over the torcular intact), across the median line, and downward to include the posterior half of the foramen magnum.

We make use of a similar technique in operations for the exposure of the medulla oblongata (see p. 635).

CHANGES IN INTRACRANIAL TENSION AFTER THE FIRST STAGE

Immediately after the mobilization of the bony parts in the lower occipital region a change in pressure in the dammed-up intra-dural fluid is immediately noticeable. Practically without exception the patients state after the first stage that they have been relieved of their greatest source of suffering—headache. In the days between the first and second stages of the operation improvement appears in the vision as well, the pain decreases and the opisthotonos diminishes. The pulse increases in frequency, and the tension decreases, which may also be referred to a decrease in the intracranial tension. However, these favorable results are likely to appear only if one has made a large opening in the skull, that is to say if both sides of the posterior fossa have been opened.

A true relief of the fluid tension may thus be obtained without opening the dura. But in the majority of cases this relief does not last for any length of time; for at the second stage of the operation the dura is found to project as forcibly into the bony opening as at the first stage. The elastic dura yields so much the more if the bony opening is large and if the occipital crest, which projects like a wedge, has also been removed, so that the dura of the other cerebellar hemisphere may also give way. Accordingly it is important to so carry out the first stage of the operation that the decrease in pressure may be as complete as possible. Particularly in tumors of the cerebello-pontine angle, the pons and the gray nuclei in the floor of the fourth ventricle are subjected to pressure not only by the tumor itself, but also by the general increase in intracranial pressure, in the same way that the optic nerve is injured.

By employment of artificial respiration, we have frequently succeeded in overcoming *disturbances of respiration*, keeping patients alive for hours after respiratory paralysis has set in, and in that way preserving their lives. At first the pulse rate and tension are affected only to a slight degree; in many patients the pulse continues to beat regularly and with full volume, so long as the respiration is maintained mechanically. In spite of the fact that active respiration had absolutely ceased, two patients maintained consciousness to such an extent that they could answer questions by nodding or shaking the head. Moreover, they moved their eyelids, although it appeared as if the muscles of the face and tongue were

completely paralyzed. In one twelve-year-old girl, with a large cyst in the right cerebellar hemisphere and in the region of the vermis, the first spontaneous inspiration occurred after artificial respiration had been continued for three-quarters of an hour. The voluntary inspirations then gradually became stronger, and we succeeded in keeping the child alive, and in curing it of its original condition at the second stage of the operation. To this class belong also those cases of general intracranial tension in which, sometimes as the result of a change of position, respiration suddenly becomes suspended and death occurs before any operative procedure may be determined upon.

In order to prevent so far as possible the bad results of increased intracranial tension and the dangers of a sudden change in pressure in the region of the respiratory center at the first stage, the cerebro-spinal fluid may be drawn off by

PUNCTURE OF THE VENTRICLE

Through a drill hole, or after enlarging the bony opening above the lateral sinus, a cannula is introduced into the posterior horn of the lateral ventricle and the fluid is drawn off until the dura over the cerebellum, and finally also the dura covering the occipital pole of the cerebrum, is seen to recede. The fourth ventricle has also been punctured without opening the dura. The result of these punctures has not, on the whole, been satisfactory. The patients after the operation feel weak and complain of headache. Ordinarily the pulse-rate rises as well as the body temperature. Not infrequently mental confusion has been evidenced in the next few days, and in several cases an increase of the nystagmus and vertigo was noticed. Furthermore, at the second stage of the operation the dura always appeared under almost the same tension as before. In no patient was any fluid seen to run off into the dressing, so that the puncture of the dura must have closed up rapidly.

In other operations on the cerebellum with an intracranial pressure which threatens danger, we have attempted to create a temporary alleviation by allowing the cerebro-spinal fluid to drain out through several incisions in the dura over the cerebellum. But the results in these cases were also unsatisfactory, because soon after the incisions were made the mass of the cerebellum was forced under strong pressure into the dural wounds, and valve-like prevented the outflow of fluid from the subdural space. Finally, in

the case of a woman who was almost completely blind as the result of choked disc, at the end of the first stage of the operation the dura was cut out in the form of a flap over the cerebellum. At the second stage it was seen that as the result of the altered intracranial tension the entire half of the cerebellum which had been deprived of its dural covering was softened so that the removal of the tumor from the liquified cerebral tissue could not be carried out with the necessary neatness and cleanliness.

Whether and how far puncture of the corpus callosum (see the section under this heading) will meet the grave dangers of increased tension in the cerebro-spinal fluid, further experience will teach us. So far our experience has given evidence of no great promise.

BILATERAL OPENING OF THE DURA MATER

For the exposure of both lobes of the cerebellum and particularly of the superior portion of the vermis, division of the occipital sinus and of the falx cerebelli is always necessary. For this purpose the dura mater is incised close below and parallel to the transverse portion of the lateral sinus to the right and left of the middle line for a good centimeter. Then a flat blunt director or aneurism needle with a sharp curve is carried carefully around the falx cerebelli at least one centimeter below the confluens sinuum, while with the index and middle finger the cerebellar hemispheres are pressed forward away from the falx. A strand of catgut is drawn through by its middle (Fig. 577), so as to include the falx, and divided. The two halves are then tied solidly about one centimeter apart from each other (Fig. 578), and the falx, together with the occipital sinus, is divided between the two ligatures. Occasionally another spurting artery must be tied off, but in our experience there has never been any bleeding from the sinus itself. Of all the sinuses, this is the most easy to ligate, because with a blunt instrument one can go around the narrow falx cerebelli. This being divided, the dura covering the two cerebellar hemispheres can be turned down in the form of flaps, after a transverse incision has been made on each side parallel to the lateral sinus, turning downward obliquely along the medial side of the sigmoid portion of the sinus.

The divided falx can now be drawn apart, and no longer offers the least obstruction. We have occasionally found it very convenient to attach the upper margin of the dura tightly to the skin

above by means of two provisional stitches, and in case of necessity make also two small accessory incisions running upward and obliquely outward from the ends of the transverse incision, in such a way as to form a small upper flap.

In many cases the cerebellar hemispheres protrude through the

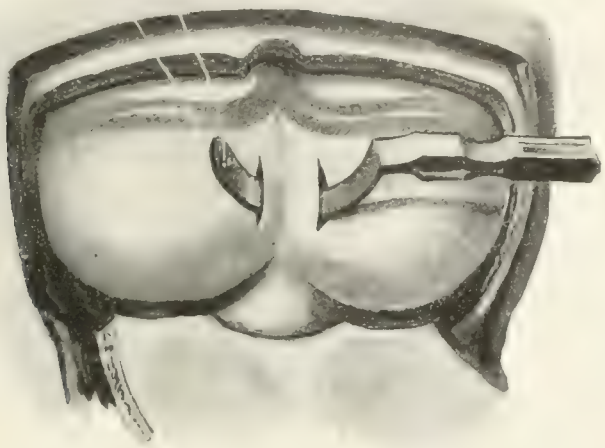


FIG. 577

Passing a double ligature about the falx cerebelli and occipital sinus.

first dural incision under strong tension, so that the director can be introduced around the falx only with considerable injury to the brain substance. In that case the falx including the occipital sinus

FIG. 578

The occipital sinus is double tied, preparatory to division.

may be divided in the middle of the two lateral incisions with blunt scissors, each cut surface being immediately seized by a hemostat, and the sinus, which does not bleed excessively, tied off.

If the two cerebellar hemispheres are exposed, ligation and division of the transverse portion of the lateral sinus and the tentorium cerebelli is unnecessary, and it may add to the difficulties. One should never tie off more than one transverse sinus on account of the danger. It is much better to lift up the intact tentorium with the brain spatula; it is remarkable how far into the depths one can view the cerebellar hemispheres and the superior portion of the vermis. In this procedure it is usual for one or more veins which run from the superior section of the vermis to the straight sinus and to the great vein of Galen, to get in the way; these are double-tied and divided. If the patient is in the sitting posture, the cerebellar hemispheres drop backward, so that one can see the lateral surfaces as well, and after lifting up the hemispheres a bit, a considerable portion of their lower surface, together with the lower part of the vermis. By drawing them out somewhat further, palpation may be satisfactorily carried on, and in case it is necessary a diagnostic incision may be made to a depth of several centimeters.

EXPOSURE OF ONE CEREBELLAR HEMISPHERE

Some surgeons consider it desirable to expose both cerebellar hemispheres in every case, whether for exploration or decompression. Cushing, in carrying out a suboccipital decompression, removes the bone covering both lobes over a wide area, as already described (p. 599), together with the exposed dura. In seeking and removing cerebellar tumors, also, he considers a free bilateral exposure of advantage, because it allows of the dislocation and outward protrusion of the normal lobe during manipulation of the other, giving easy access to the tumor, with less likelihood of affecting the medullary centers by pressure from retraction.

In operating upon a cerebellar abscess or for a tumor which has been exactly localized in one hemisphere, according to our experience an osteoplastic flap which includes the area corresponding to the affected hemisphere gives a satisfactory exposure. The upper incision runs above the superior semicircular line from the external occipital protuberance to a point near the posterior margin of the mastoid process. One keeps a little away from the mastoid, in order to avoid the mastoid foramina and the large emissaries which come through them. For this very reason the lateral bony incision is made last, for if an emissary is met at this point, with the incisions made in this order, one has the great advantage of being able to

complete the formation of the flap immediately by completing the final lateral bony incision, and is then able to rapidly turn back the osteoplastic flap. Only two drill holes are necessary at the upper corners of the incision; they should be made either exactly over the transverse sinus or just above it over the dura of the occipital lobe.

To complete the operation the dural flap is made on the affected side with its base below, by carrying the incisions close along the sinuses, the transverse and sigmoid portions of the lateral sinus, and the occipital, in order to get as unobstructed a view as possible. Frequently such an exposure has sufficed for removal of tumors of the auditory nerve. But if the cerebellum cannot be displaced sufficiently to the medial side, the occipital crest must be removed, and the dura incised upon the other side close to and parallel to the occipital sinus, so that this can be double-tied and divided (see p. 603) in such a way as to expose a portion of the other hemisphere.

INSPECTION OF ALL THE SURFACES OF THE POSTERIOR FOSSA AND OF THE CEREBELLUM

For a careful examination of all the surfaces of the cerebellum, the technique is employed which Krause described in 1898.* Above all things, the pia mater and, if possible, the arachnoid, which covers the cerebellum, should never be injured. In spite of its thinness it holds very well, for every incision, particularly if the cerebral tension is high, causes an immediate protrusion of the cerebellum in varying degree, which renders the view into the depths most unsatisfactory, if it does not completely obscure it.

If one is operating with the patient in a sitting posture and the tension is slight, the posterior surface of the petrous portion of the temporal bone can be approached over a limited extent by lying the head over on the normal side. The exposed hemisphere then falls to the other side without it being necessary to touch it. In this manner the bony surface of the petrous portion may be so far exposed as to allow one to reach a vein which ordinarily runs over from the superior petrosal sinus into the cerebellum, and if necessary to tie it off (Fig. 581). To proceed further a flexible brain spatula (see Fig. 579) which may be readily adapted to any surface is necessary; and the retractor which Krause originated for

* F. Krause: Zur Freilegung der hinteren Felsenbeinfläche und des Kleinhirns. Beitr. z. kl. Chir., Vol. 37, p. 728.

extirpation of the Gasserian ganglion is useful here (Fig. 580). All displacement of the cerebellar hemispheres is carried out with the utmost care, by very slowly and gradually increasing the pressure to the necessary amount. In this manner dangerous effects upon the centers of circulation and respiration can, as numerous experiences have taught us, be well avoided even here.

As a rule, the cerebellum is displaced in the following manner:

1. Medially (see Fig. 581); by this maneuver the upper section of the posterior surface of the petrous portion of the temporal bone comes into view, together with the points of entrance of the auditory and facial nerve into the internal auditory meatus; by further

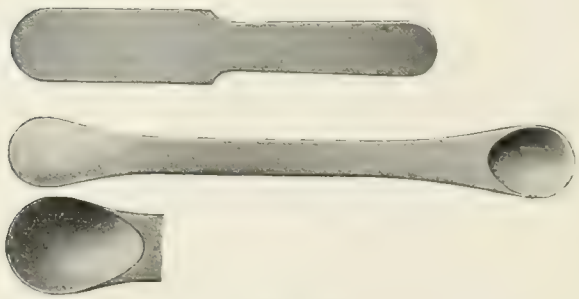


Fig. 579
Brain spatula.

Fig. 580
Krause's retractor, used in extirpating the Gasserian ganglion.

displacing the cerebellum medially, these nerves are rendered visible in their course backward to the pons.

2. Obliquely inward and upward (Fig. 582); by this displacement one is able to observe the glosso-pharyngeal, the vagus and the spinal accessory nerves.

3. Directly upward (Fig. 583); by this procedure these three nerves are made to stand out more clearly still, together with the entire base of the posterior fossa. Particularly it can be seen how the accessory nerve runs up from below out of the spinal canal. The lateral portion of the medulla oblongata also comes into view.

4. Downward, so that the upper surface of the cerebellar hemispheres may be examined. Elevating the tentorium cerebelli with the spatula gives the same result.

All the displacements described give a clear picture, and one can at his leisure examine the conditions in the depths and determine whether or not any tumor is present in the neighborhood of the hemispheres or in the posterior fossa. The examination described of all the surfaces of the cerebellum and of the sections of the bone with which they are in apposition can be carried out easily if the

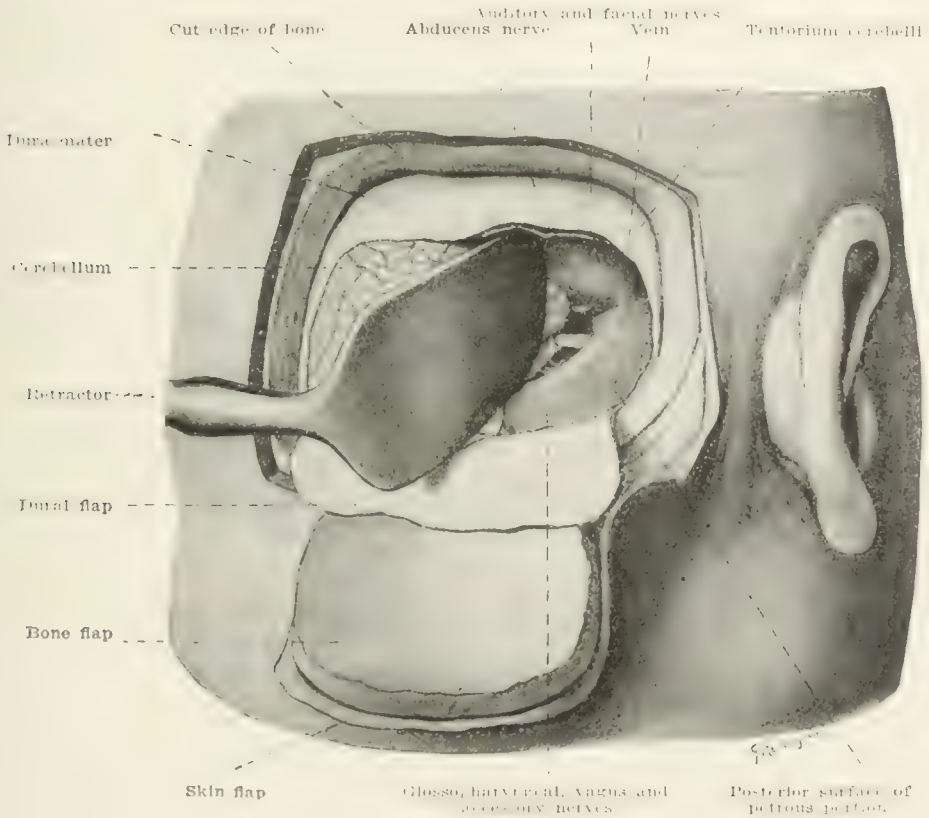


FIG. 581

Intradural exposure of posterior surface of petrous portion of temporal bone.

intracranial pressure is slight. But if the pressure is high, as is usually the case with solid tumors, the technique is much more difficult.

Particular care must be taken of single veins which run upward from the upper surface of the cerebellum and the region of the vermis to the tentorium cerebelli, or which empty into the lower wall of the transverse sinus. If they get in the way they should be double-tied and divided; if they are carelessly torn away, they

may give rise to a considerable hemorrhage, particularly from the wall of the sinus itself. Venous hemorrhage, if the bleeding lumen

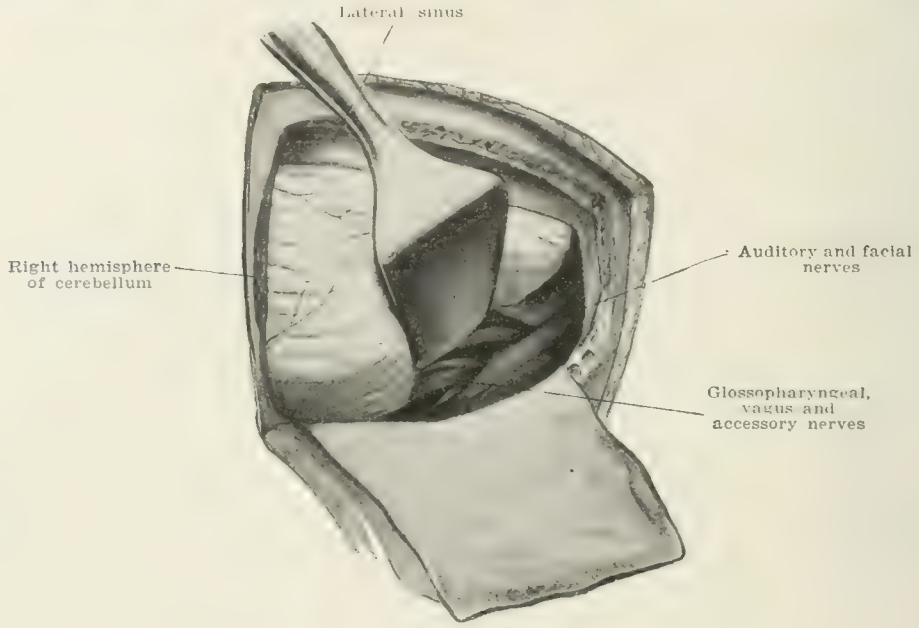


FIG. 582
Displacing the cerebellum upward and medially.

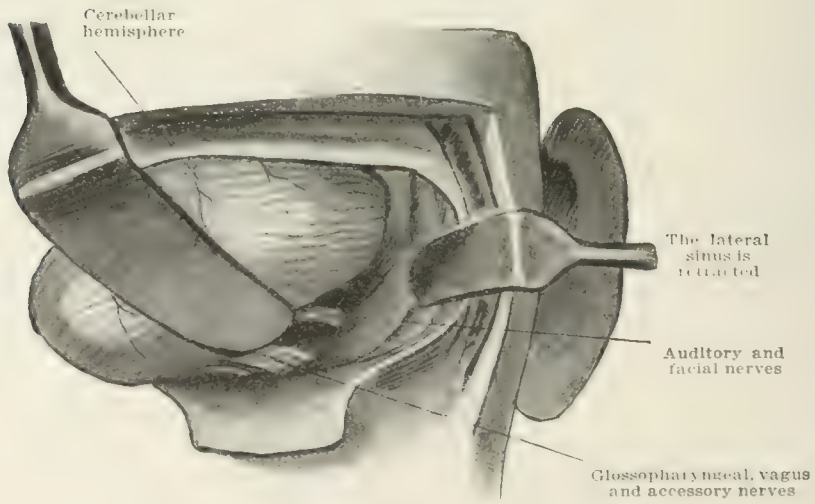

Cerebellar hemisphere
The lateral sinus is retracted
Auditory and facial nerves
Glossopharyngeal, vagus and accessory nerves

FIG. 583
Displacing the cerebellum upward.

can be recognized in the obscuring hemorrhage which immediately follows, can, according to our experience, always be controlled by compression with gauze sponges.

INTRACRANIAL EXPOSURE AND RESECTION OF THE AUDITORY NERVE

Krause demonstrated in July, 1898, the possibility of exposing the petrous portion of the temporal bone over a considerable extent by the intradural route through the posterior fossa, when for the first time he resected the auditory nerve at the internal auditory meatus. The sixty-three-year-old patient, although completely deaf in this ear, was reduced to desperation as the result of the most agonizing subjective roaring. This operation, performed by Krause four times, should be given a definite place in surgery, for there are patients in whom such symptoms combined with a permanent deafness cause great suffering, and even lead to suicide. We shall describe one of these cases. Charles H. Frazier, in 1908, has also performed this operation for persistent oral vertigo.*

A young man of twenty-nine years had, at the age of twelve, noticed a buzzing in the right ear, and from that time on he was continually under treatment by aural and nervous specialists. Up to the twentieth year he was able to devote himself to his education, but after that he had to give up his career as an army officer on account of the disease. From 1907 on he was almost entirely deaf in the right ear, and after the middle of 1909 he was completely so.

The roaring which the patient experienced in this ear alone continued practically without exception day and night. He described it as if hundreds of children were holloaing continually without interruption. The sensation was not interrupted by any other noise, such as, for example, that of a train of cars. At times it was so painful that the patient threw himself upon the ground and beat his head with his fist. When the roaring became worse on the right side, the patient heard practically nothing with his left ear; but if the noise became less severe, as it occasionally did, he was able to hear well with the left ear.

His entire nervous system was undermined by the disease. The persistent suffering which was so agonizing that in comparison all other pain was slight, had reduced the patient to a condition of neurasthenia of such degree that he finally had to be placed in an asylum on account of his maniacal attacks. Moreover, the sleep-

* Intracranial Division of the Auditory Nerve for Persistent Aural Vertigo. Surgery, Gynecology and Obstetrics, Nov., 1912, p. 524.

lessness which he suffered as the result of the roaring in the ear, and to counteract which all narcotics were powerless, completely exhausted the patient and made him useless for all physical activity, even that of walking. This was his condition when, at the end of December, 1909, he came into our hands.

On December 30, 1909, we divided intradurally the auditory nerve in one stage. The osteoplastic flap was planned in the typical manner for the exposure of the right cerebellar hemisphere, so that the transverse sinus appeared in the upper part of the opening (Fig. 584, Plate 96). Laterally, however, the sigmoid portion of the sinus could not be seen, but since the operation was to proceed exactly in the region between it and the posterior surface of the petrous portion, another strip of bone was removed laterally until the sigmoid sinus was exposed. In this procedure one emissary vein bled above, but the hemorrhage was controlled by hammering the diploë with the Passow chisel.

After the dural flap was formed (Fig. 585, Plate 96) and turned downward, the cerebellum was found to present very slight pulsation and not the least tension, both in marked distinction to the findings in the presence of tumors. On displacing the right cerebellar hemisphere toward the medial line with the brain retractor, the auditory nerve came into view at a depth of about 4 cm., measured from the dura (Fig. 586, Plate 96). By displacing the cerebellum still further to the middle line, the common nerve bundle containing the auditory and the facial nerves was visible for a good centimeter, so that further displacement was unnecessary. Examination showed a fine line or minute furrow on the surface of the shining, white, cordlike bundle, which evidently represented the division between the two nerves, the auditory on the outer side and the facial on the inner (shown twice normal size in Fig. 587, Plate 96).

Medially to this nerve bundle there came into view a vessel which split into two parts; it looked like an artery, but showed no pulsation, which might be explained by its small caliber. As it entered the internal auditory meatus just above the nerve bundle, it was evidently the internal artery. About 3 cm. farther toward the middle line one could see the abducens nerve running along for about 3 mm. on the upper edge of the petrous portion.

The hemorrhage being very slight, and readily controlled by pressure with small sponges which were introduced into the apex

Intradural division of the auditory nerve, after F. Krause.

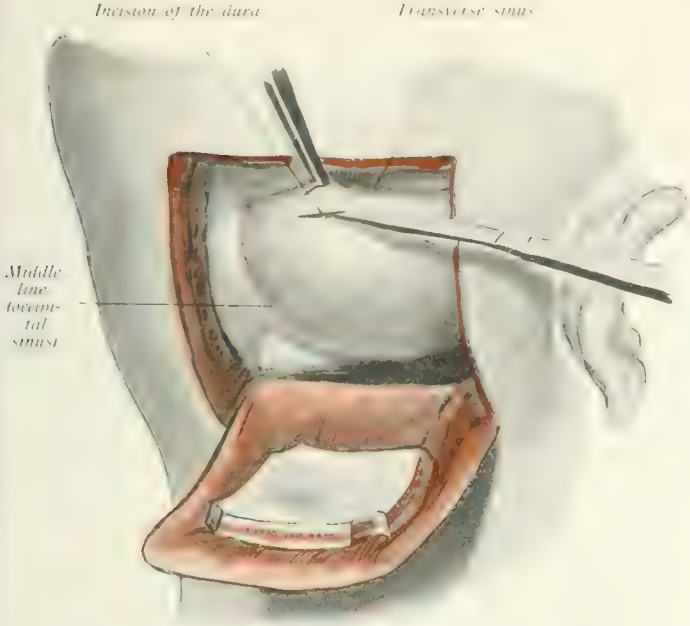


Fig. 584. Exposure of the right posterior fossa.

Fig. 585. Cutting the dural flap.

Fig. 586. Exposure of the internal auditory meatus.

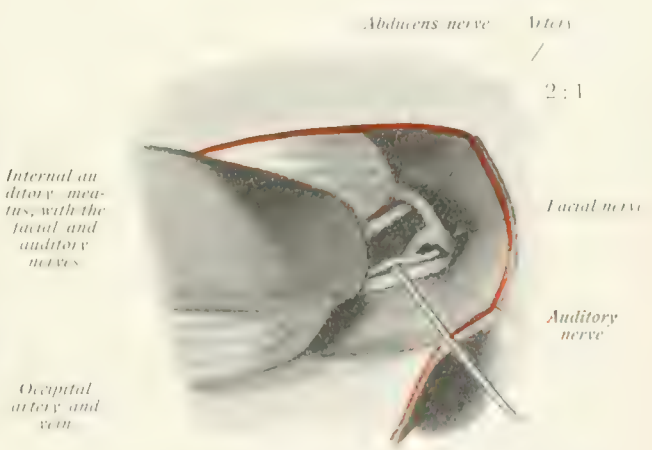


Fig. 587. Separation of the auditory from the facial.

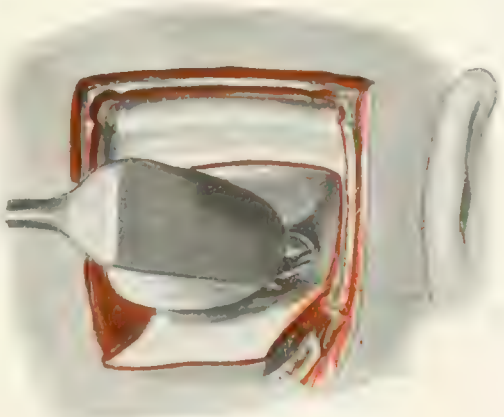


Fig. 588. Operation completed.

of the deep funnel-like wound, the isolation of the auditory nerve could be undertaken. This can be done without necessarily injuring the facial nerve with which it is in close contact. In the first place, the auditory nerve is particularly soft, to which it owes the distinction of having been formerly called the *portio mollis*, the facial being called the *portio dura*, of the seventh nerve. Moreover, nerves which run within the dura have no connective tissue sheath, as they first receive their neurilemma on their exit through the dura. Finally, the auditory nerve lies to the outside of the facial and, accordingly, is the first to be reached from without; it has a channel hollowed out on the inside in which the facial nerve is contained.

The separation of the auditory from the facial was carried out by introducing the finest blunt-pointed strabismus hook from below into the split. The auditory nerve was divided with a knife, cutting against the hook which acted as a guide, until the facial nerve was seen to lie free. The divided auditory nerve was displaced backward, so that it rested against the cerebellum (Fig. 588, Plate 96).

Unipolar Faradic stimulation of the facial with the weakest current from the slide induction coil gave contractions in the right facial region, particularly in the orbicularis palpebrarum, as well as in the nerve distribution to the nose and mouth. This ended the operation. The dural flap was sewed in place with two sutures, the wound was closed without drainage by interrupted sutures, and after removal of the hemostatic suture strong compression was applied in the neighborhood of the dressing.

The wound healed normally, there was no rise of temperature or pulse, nor any flow of cerebro-spinal fluid. The highest temperature on the evening of the second day was 100.2, and the highest pulse rate at the same time was 88. At the first dressing, eight days after operation, the wound was found healed and the stitches were removed. On this day there was noted for the first time a paresis in the middle and lower regions of the facial distribution on the right side, which for the first few days involved slightly also the orbicularis palpebrarum. From January 20th on the facial paresis gradually diminished, and on January 21st the patient could again whistle and partly close the eye. On the 25th the paresis was very slight, and on the 30th it was completely gone. On January 23d the patient said that he could see double; this disturbance, which could not be objectively demonstrated, passed over immediately.

The general condition of the patient changed after the operation to such a degree that he became much more quiet. To be sure the roaring still continued in the right ear, but it no longer disturbed in any appreciable degree the hearing in the left ear; the nature of the sounds was changed markedly, and they could be much better borne. The patient now localized the sound in the neighborhood of the wound and no longer in the right ear.

According to written reports, the subjective roaring continued until the end of February, 1910, at times in severe degree, so that the patient could be comforted only by his good general condition, which had been induced by long walks. Then gradually he began to show improvement. In a letter written in March, 1913, he expressed himself as happy over his present condition; the roaring, to be sure, was only infrequently absent, but on many days it was insignificant. But particularly after exposure to cold and after physical exercise, that is to say, when the blood pressure was increased in the head, it became more severe.

REMOVAL OF TUMORS AT THE CEREBELLO-PONTINE ANGLE (TUMORS OF THE AUDITORY NERVE)

Of the solid tumors in the posterior fossa, the most frequent in our experience are those which occur in the angle between the cerebellum and the pons. They have been known for many years as auditory neuromas, and at the present time, since the monograph of Henneberg and Koch, they are called tumors of the cerebello-pontine angle. Usually of a benign nature, they are fibroma or fibro-sarcoma. As a rule they are encapsulated, and shell out easily; accordingly they represent a fairly simple problem for the surgeon when unilateral. They may, however, be bilateral or even multiple. During their growth they displace to one side the cerebellum medulla and pons, and produce corresponding symptoms. The figures on pages 614 and 615 represent such tumors.

Among the more important clinical manifestations which they arouse are to be mentioned headache, vomiting, loss of consciousness, convulsive attacks, vertigo, lack of stability with the eyes closed, cerebellar ataxia, choked disc, buzzing in the ears, disturbances of hearing, and nervous deafness on the same side as the tumor. Diplopia, occasionally becoming stronger toward the side of the tumor (weakness and paralysis of the abducens), occasionally participation of the motor oculi and trochlear, nystagmus when the

eyes are directed to one side, finally with limitation of vision on the side of the tumor, may also occur, as well as loss of the corneal reflexes on the side of the tumor, sensory disturbances in the trifacial region, paresis of the muscles of mastication, facial paresis, participation of the glosso-pharyngeal, vagus and spinal accessory nerves, adiadochokinesis on the side of the tumor, and

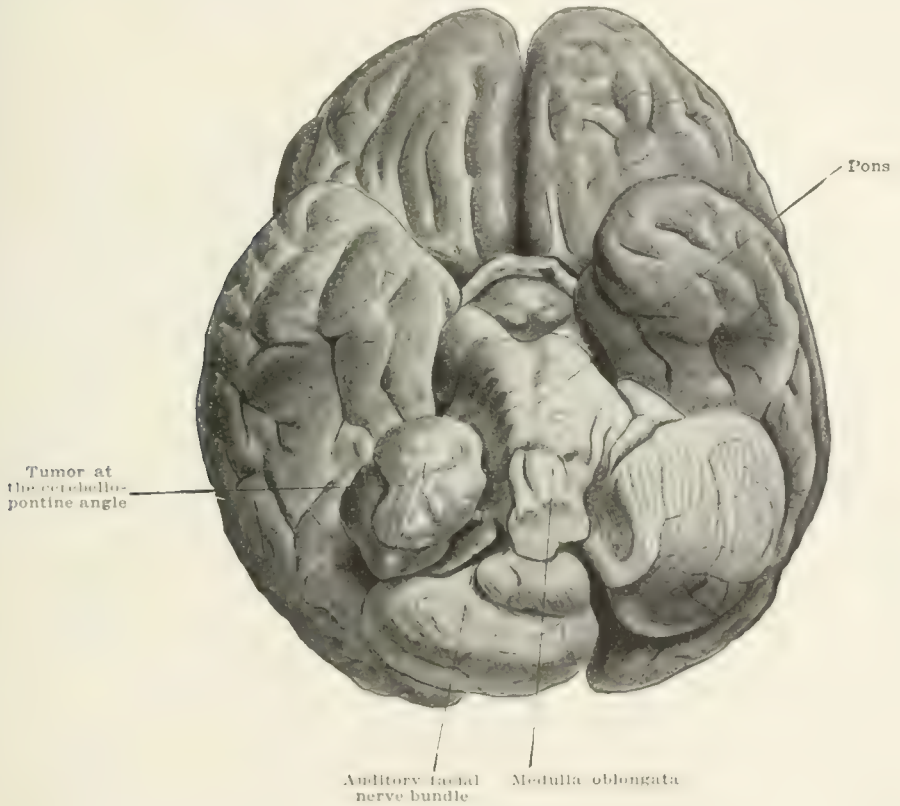


FIG. 589

Position of a cerebello-pontine angle tumor.

ataxia of the hand. There may be lack of assurance in walking and standing, changes in the reflexes, and loss of the caloric reaction on the side of the tumor. Deviations from the normal are shown by the Bárány test. Pressure over the corresponding mastoid process may elicit pain.

The removal of the tumor, which lies in the angle between the cerebellum, pons, and the posterior surface of the petrous portion, is most easily carried out if the growth takes its origin from a nerve trunk, the auditory, for instance, has developed isolated from the

neighboring portions of the brain, and is well encapsulated (Fig. 589).

Tumors of this type at times come out to meet the operator, so to speak; if, after opening the posterior fossa, he displaces the cerebellum medially with the retractor, they may be easily shelled out; only a few fibers have to be cut with scissors. Conditions were thus favorable in the twenty-one-year-old man represented in Fig. 590. But they are more difficult if the tumor, although readily

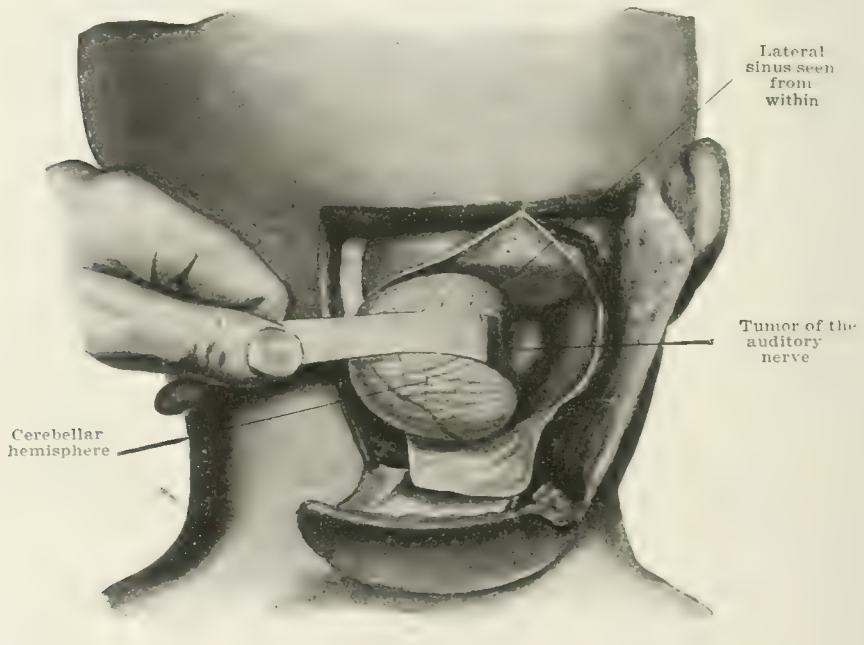


FIG. 590
Cerebello-pontine angle tumor in a twenty-one-year-old man.

differentiated from the cerebellum by its color and density, has grown fast to the surrounding tissues. Then it must be shelled out with the greatest of care.

The tumors are not always to be easily differentiated. Occasionally the color of the neoplasm is like that of the brain substance, and the slight differences are negatived by the fact that the arachnoid covers cerebellum and tumor in common, and the vessels also pass over the two structures without interruption (Fig. 591). By means of this common covering, the tumor may, moreover, be so closely united to the cerebellum that the two are moved as one. Then we must first separate this capsule, which, on account

of its delicacy, is usually successfully done by wiping with a sponge or tearing with anatomical forceps, in order to appreciate the furrow which marks the line of separation between cerebellum and tumor.

The consistency of the tumor varies, and may offer great difficulties in the extirpation. When it is of a firm consistency, it may be readily shelled out by blunt dissection, best with the assistance of small sponges, which are employed alternately with a narrow flexible retractor or spoon. The most reliable instrument—the

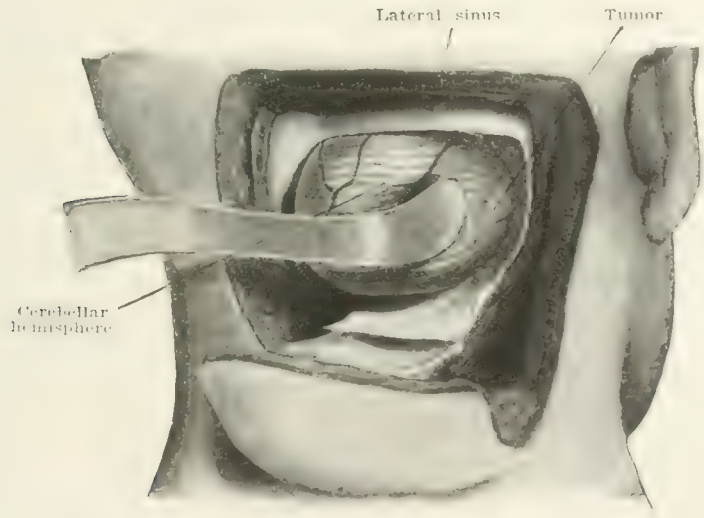


FIG. 591

Cerebello-pontine angle tumor in a forty-six-year-old man, recognizable only by the very slightest protuberance.

sensitive finger—in most cases cannot be employed in this narrow field, partly because it takes up too much room, and partly because it may exert a direct and dangerous pressure upon the medulla oblongata. One proceeds very slowly in all manipulations so that the vital portions of the brain pressed upon may gradually adapt themselves to the necessary displacement.

One can proceed more energetically along the posterior surface of the petrous portion, in so far as the facial and auditory nerves are not involved, which naturally must be given all possible consideration. Thus, as will be seen later, we have occasionally succeeded in preserving both nerve trunks. When the tumor has been freed up from the surface of the petrous portion and from the

cerebellum, the portion which still remains attached is drawn out of the depths with a blunt curette or with a flexible spatula.

IMPOSSIBILITY OF RADICAL EXTIRPATION

Several times in operation on tumors of the cerebello-pontine angle, we have found the growth firmly attached to the posterior surface of the petrous portion of the temporal bone at the internal auditory meatus. We have three times seen it penetrate into the bony substance, so that after the tumor was removed there was left behind a rough irregular surface about the size of a quarter dollar which had a gnawed-out appearance resembling caries. Generally speaking, in such cases radical operation is impossible.

Extirpation may be difficult and even impossible if the tumor is very extensive, and at the same time is friable and falls apart on the necessary manipulation. And one is even less successful in removing tumor masses which lie medially in the cavity of the pons, if they extend over on to the posterior portions of the brain, or if they have progressed into the middle fossa.

Such tumors are always impossible to extirpate; unfortunately we can never make the diagnosis of a wide extension of the tumor before operation.

EXTIRPATION OF A TUMOR OF THE CEREBELLO-PONTINE ANGLE

Oppenheim, in a man thirty-four years old, on the basis of evidence of cochlear and vestibular symptoms, made the diagnosis of a cerebello-pontine angle tumor on the left side. A slight paresis was present over the left facial area; on extending the tongue it deviated somewhat to the left. The fundus on both sides showed marked choked disc. The visual acuity was on the right side five-tenths, and on the left, five-sevenths. On the left side there existed an areflexia of the cornea. While the other movements of the bulb were free, weakness of the abducens could be demonstrated particularly in the left eye. With the eyes directed toward the left side, a coarse, irregular nystagmus occurred which, on turning the eyes to the right, became more defined, finer, and more rapid.

Tests of hearing showed that on the right side the patient could hear a whisper at a distance of five and one-half meters, but on the left only just in front of the ear. Tuning-fork tests showed that the Weber was definitely lateralized to the right. The tuning-fork (A) was not heard at all on the left side by aerial conduc-

Enucleation of a tumor of the cerebello-pontine angle.

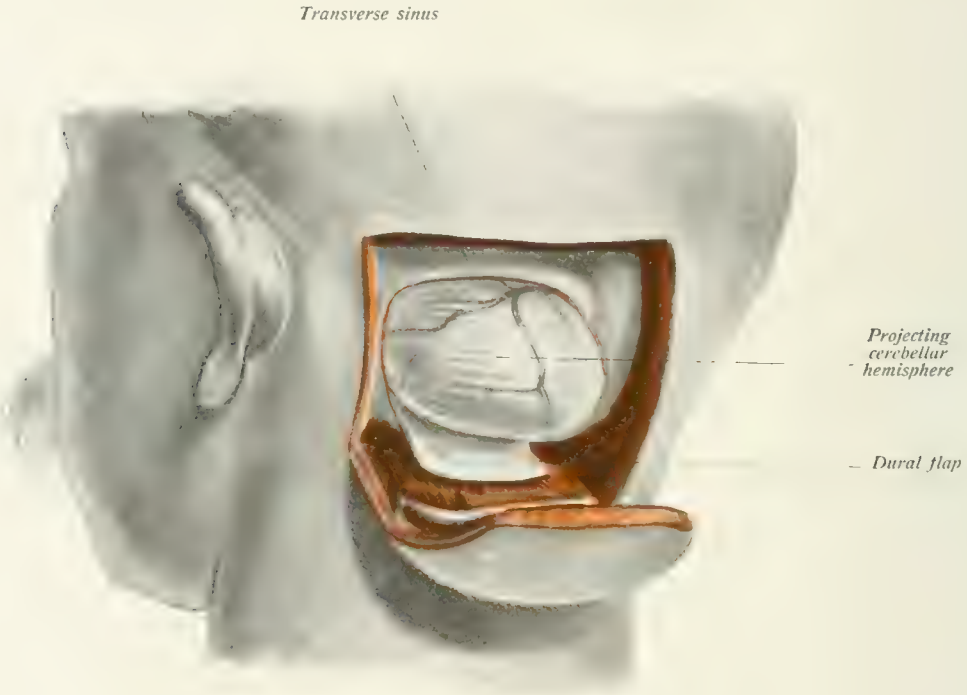


Fig. 592. Exposure of the left cerebellar hemisphere.

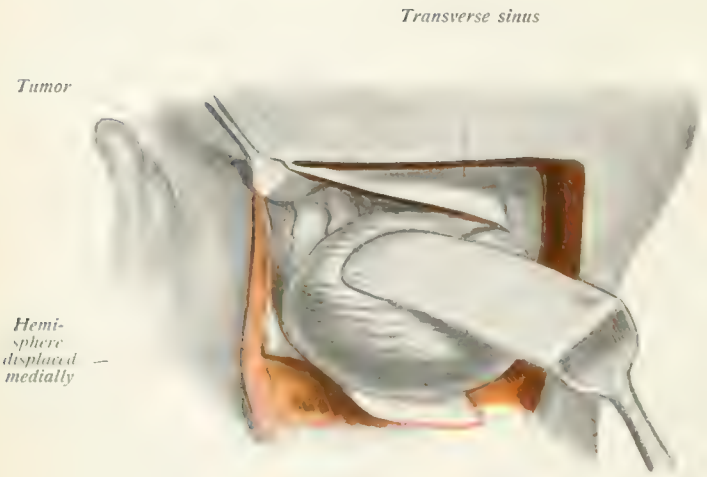


Fig. 593. Exposure of the tumor.

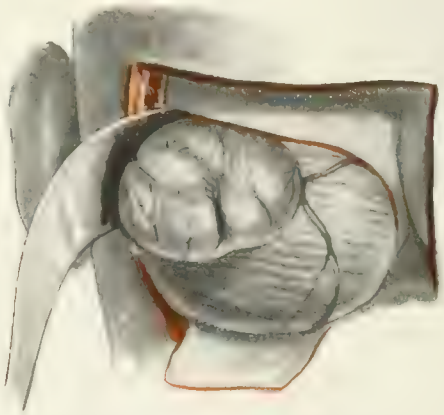


Fig. 594. Enucleation of the tumor with a large dull curette.

tion, but was heard by bony conduction as long as upon the right side where the aerial and bone conduction were normal. A1 and fis4 were heard on the right side to the end, but on the left were much reduced. Examination with Galton's whistle could not be depended upon, since it was apparently not heard in the left, but in the closed right ear.

The caloric reaction was negative in the left ear, but in the right it appeared promptly. Even before half a pint of water had been injected, the patient complained of vertigo, and the nystagmus on looking toward the left was increased, and on looking toward the right it was not altered. After the syringing, the ataxic disturbances in walking were exaggerated to a marked degree. Subjectively the patient complained of a buzzing in the left ear. At that time the Bárány test was still little known.

The test for ataxia showed evident disturbances. On closing the eyes there was a marked swaying; the gait was the typical cerebellar ataxic. The attempt to place the heel on the opposite knee showed a motor ataxia in the left leg. This was not present in the left hand, but there was, however, marked adiadochokinesis. On the left side Oppenheim's test was present, and an uncertain Babinski.

Operation was performed October 11, 1909. The left posterior fossa was exposed in the regular manner with preservation of the bone flap. The dura did not pulsate, but it felt as hard as a billiard ball. The second stage was performed nine days later. The dura was turned down in the form of a flap with the base below. The cerebellar hemisphere which protruded and was now pulsating (Fig. 592, Plate 97), was retracted medially with a brain spatula, which brought the tumor immediately into view about two cm. below the dural surface (Fig. 593). It was visible over its entire circumference after the dura at the angle of the transverse and sigmoid portions of the lateral sinus was lifted upward and outward with a blunt retractor.

The tumor showed a coarsely granular surface of a grayish-red color with yellow spots scattered over it. An attempt to deliver it by means of suction failed, because it was too soft, and in its consistency could not be readily differentiated from the cerebellum. For that reason it was first freed up from the posterior surface of the petrous portion and from the tentorium cerebelli by means of a large flat blunt-edged spoon. In this manner we succeeded in

reaching the anterior pole of the neoplasm and by means of pressure at this point were able to separate it from the petrous portion, to displace it backward, and finally to remove it (Fig. 594).

The cavity which remained had a depth, measured from the surface of the dura, of 48 mm. Since the floor of the cavity showed normal brain substance everywhere and the hemorrhage had ceased, the cerebellum which had previously been displaced toward the middle line was now replaced laterally into the cavity which was formerly occupied by the tumor, and the wound, after sewing up the dural flap, was closed tight. Microscopic examination showed a fibroma rich in cellular elements.

The patient stood the operation well and the wound healed without incident. By October 26 it had scarred over except for a small space which remained open in the middle line, through which came away cerebro-spinal fluid in greater or less amount. When the dressing was dry, that is to say, when the fluid was retained within the cranium, the patient reacted by means of a rise in temperature (for instance, on October 27 the temperature rose to 103.4, on November 4 to 100.4, on November 8 to 101, and on November 16, for the last time, to 100.4) which was accompanied by severe headache in the frontal and temporal regions and particularly by lancinating pain in the left ear. The accompanying rise in pulse rate was moderate and only on the 27th of October did it reach 110. Otherwise it never went beyond 88. After November 22 no further secretion of fluid was observed and the wound had healed completely. The patient had a normal pulse and temperature after the 17th, and after November 22 there was no further headache.

From the psychic point of view the patient showed nothing abnormal after healing was completed. The euphoria and clownish tendencies were recorded by the patient as simply a reckless sort of merriment. After the 17th of November the patient was out of bed feeling subjectively very well, and he was discharged on December 7.

In March, 1912, two and one-half years after the operation, the patient reported in an excellent physical condition, all subjective symptoms having disappeared. No disturbances of innervation of the facial and hypoglossal nerves were to be seen. The abducens paresis had disappeared, except that in looking toward the left, the left eyeball did not fully complete the arc of motion; nystagmus still persisted in a very slight degree, but on looking toward the

right, it could hardly be made out. The areflexia of the cornea showed hardly any improvement, and on the right side also the corneal reflexes were much diminished. The vision, according to the patient, had improved; the left-sided deafness was unchanged. Of the ataxic disturbances a slight motor ataxia persisted in the left leg. The gait still showed something of the cerebellar ataxic character, but the patient walked with assurance and without swaying. With the eyes open he could stand solidly, but with the eyes closed he would occasionally sway toward the left side. The reflexes were normal.

The fundus was normal. The operated side projected slightly and gave a slight sense of fluctuation; the patient had never found it necessary to wear a protective apparatus.

EMPLOYMENT OF SUCTION

In order to be as considerate as possible of the pons and medulla, we can use suction in this class of tumors as well as in those already described (see p. 530). In tumors of the cerebello-pontine angle it may be employed with particular advantage if, as above-stated, the tumors lie loose in the hollow which has been created by their growth. If the tumor comes into view after retracting medially the affected cerebellar hemisphere, and the thin capsule is torn through, suction may be applied to the posterior free surface, and while the tumor is gradually drawn out the brain substance is very carefully stripped backward with small sponges. In this manner one can bring to the surface even unusually large tumors with the greatest of consideration.

As an example of the technique we give the following operative history of a man thirty-nine years of age.

In this case there appeared as the first symptom a sudden diminution of vision in both eyes, and the patient, in stooping over, fell to the ground with vertigo. The inunction treatment ordered by the physician was ineffective, so that the patient five months later was sent into the hospital for observation. Except for intermittent pains in the occipital region and vomiting, there existed a choked disc on both sides, to a higher degree on the right, right-sided abducens paralysis, areflexia of the cornea, facial paresis, nervous deafness and hypoglossal paresis. In the right extremities the motor power was distinctly lessened, as well as the knee and elbow reflexes.

Pathological reflexes were present in both feet. In addition there was cerebellar ataxia and right adiadochokinesis.

The operation was performed in two stages with an interval of twelve days, because the patient recovered slowly from the first operation as the result of a considerable venous hemorrhage. After cutting out a flap in the dura the cerebellar hemisphere fell completely out so that it lay about 1½ cm. in front of the dura. The cerebellum being retracted medially and somewhat downward there came into view a tumor with a smooth nodular surface resembling the cerebellum in color and arrangement of vessels, but of a slightly firmer consistency (Fig. 595, Plate 98). On letting go of the retractor the posterior surface remained visible.

By tearing the pia which covered it with forceps, the smooth upper surface was exposed, and by blunt dissection with gauze, the posterior circumference. Then the posterior pole was seized with the suction glass and by frequently interrupting the suction, we were gradually able to displace the tumor backward. Naturally we proceeded with careful regard to the neighboring pons and medulla, with extreme slowness, and at the same time pushing the cerebellum clear from the tumor with sponges (Fig. 596, Plate 98). This technique having accomplished its purpose, the upper surface of the tumor was carefully freed from the tentorium, to which it had not become adherent, with the brain spatula.

As the tumor now projected some distance backward, the suction glass could be shoved downward for a centimeter or more over its posterior pole, which already projected a centimeter beyond the dural surface (Fig. 596). To be sure the cerebellar hemisphere was sucked backward at the same time, but not nearly so far as the tumor. At any rate this was brought out where it could be readily manipulated. Finally the tumor, being drawn out into the cylinder, was exposed practically for its entire length, and it was carefully loosened up from its bed with the flexible brain spatula, while at the same time the gradual and careful suction was continued. In this way we succeeded in sucking out the tumor completely uninjured within its capsule, as was shown by the vessels running over it, and to include the anterior pole with the blunt spoon (Fig. 597, Plate 98).

In spite of the careful manipulation, the patient at this moment, although he had already partially awakened from the anesthesia, suffered a severe collapse which announced itself chiefly by cyanosis

Suction applied to a tumor of the cerebello-pontine angle.

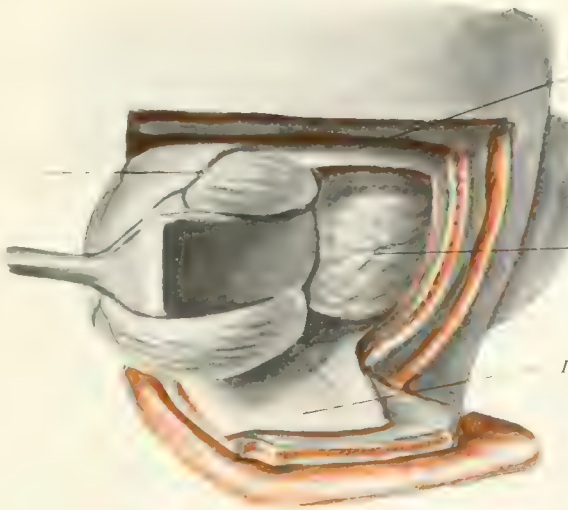


Fig. 595. Exposure of the tumor.

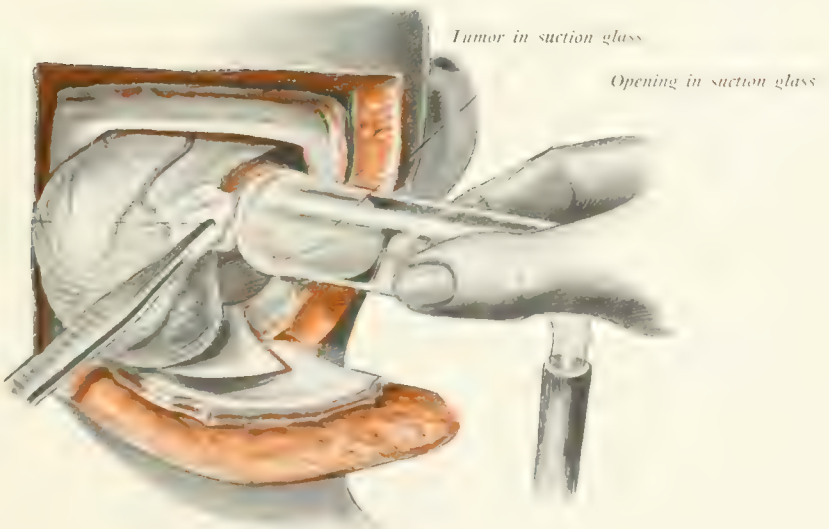


Fig. 596. Suction applied.

Fig. 597. Freeing the tumor by means of a blunt curette.

with impaired respiration, while the pulse remained at 80, regular and of good volume; the loss of blood during the entire operation had not been more than a teaspoonful. The collapse was overcome by depressing the head and pulling out the tongue sharply. After turning up the dural flap, the skin and bone flaps were sewed in place with the head extended backward as far as possible. An hour after the suture was completed the pulse was 64, full, regular, and of moderate tension, and the respiration was again unimpeded.

At one part of the tumor there ran across the surface a cord one-half millimeter thick and three cm. long, which looked like a nerve with its accompanying vessels. The largest diameters of the tumor were 45, 37, and 29 mm.

The patient ran an uneventful course without fever during the first week; the temperature did not rise above 99.5, nor the pulse above 88; the choked disc diminished, and the vision increased about 30 per cent. On account of saturation with cerebro-spinal fluid the dressing had to be renewed every second day. On the fifth day the sutures were removed and the wound showed primary union. There still leaked out a little clear fluid from the right upper corner of the wound. On this evening the temperature rose to 101.3, but it came down to normal and remained so for two days; the pulse did not exceed 88.

Nine days after the operation the temperature for the first time reached 102.6, the pulse 120, and they remained at this level for an entire week, without the least sign of meningitis appearing. The patient insisted that he was feeling well. Up to the 12th day after the operation the fluid which came away was entirely clear. Sixteen days after the operation the temperature fell to 99.8, while the pulse continued at 120. On the next day the patient died with manifestations of vagus paralysis and cardiac weakness.

Autopsy (Professor Östreich) showed the tumor bed in the pons and the medulla free of remnants of the tumor, but a slight softening of the substance of both these portions of the brain in the neighborhood of the tumor bed with small parenchymatous hemorrhages; there was no trace of meningitis.

EXTIRPATION OF AN ARACHNOIDAL SARCOMA OF THE POSTERIOR FOSSA

The much less frequent tumors in the posterior fossa which arise from the arachnoid and pia (usually fibro-sarcoma) are removed,

if they are located between the cerebellum and the petrous portion of the temporal bone, in the same manner as tumors of the auditory nerve. The following case is an example of this sort; in this class of cases we meet the largest neoplasms which we have occasion to remove in this region.

The case was one of a twenty-one-year-old girl in whom the diagnosis was made on the following grounds. Nystagmus, areflexia of the cornea and adiadochokinesis showed in conjunction with manifestations of intracranial pressure a new growth in the posterior fossa; central deafness of the left ear and motor disturbances in the left hand pointed to the left half of the cerebellum, and clearly defined manifestations of meningeal irritation to a basal tumor extending as far as the spinal canal. The tumor was likely to be found in the neighborhood of the cerebello-pontine angle. The X-ray plate showed nothing pathological.

On May 15, 1913, the first stage was performed. Without hemostatic suture, the skin and bone flap was formed after tying the two occipital arteries in the typical fashion, exposing the entire left cerebellum up to a point 3 cm. behind the origin of the shell of the left ear, and on the right side extending only 3 cm. beyond the middle line, 6½ cm. from the attachment of the right external ear. The dura was under exceedingly strong tension and showed no pulsation. Beneath it, over the left hemisphere, there lay a bluish structure which showed through, as if hemorrhagic fluid were present under the dura. On puncture only a few drops of clear fluid appeared; the coloration evidently belonged to a solid mass, which showed tension, but no fluctuation.

The second stage was carried out May 21, 1913; a few grams of chloroform sufficed for the anesthesia. After the occipital sinus was double-tied and divided, the entire surface of the dura was turned down in the form of a flap. There immediately came into view in the left posterior fossa a bluish-red spherical tumor, which lay in close apposition to the left petrous portion of the temporal bone, extended backward to the tentorium, and rested below on the floor of the cranium. This last circumstance explained the marked laryngological symptoms (vagus nerve).

On its median half the tumor was covered by a thin layer of the left cerebellar hemisphere; this was displaced medially with the finger. Then we freed carefully with the forefinger the medial aspect of the tumor from the vermis to the lateral region of the

pons and displaced it somewhat backward. Then we were able to free up the tumor from the posterior surface of the petrous portion, from the lower surface of the tentorium, and from the base of the skull with the finger, and completely enucleate it. The tumor was practically spherical, larger than a cerebellar hemisphere and measured from before backward 66 mm., from right to left, 52 mm., and from above downward 54 mm.

There was no hemorrhage on the medial side of the tumor bed; apparently the vermis, pons, and cerebellum had only been displaced to the right. But there was on the other hand hemorrhage from the region of the base of the skull, and from the angle between the petrous portion and tentorium, in moderate degree, both arterial and venous. Pressure was exerted against these vitally important sections by means of two gauze strips and layers of muscle, while the medial aspect of the bed of the tumor was carefully examined. Nowhere could any remnant of the tumor be seen. Even the pia covering the nerve centers was not disturbed, except for a small portion of the left cerebellum, where the medullary layer had been exposed in enucleating the tumor.

According to the pathological findings it was not a true cerebello-pontine angle tumor. Large tumors of the auditory nerve do not usually extend so far backward. As a rule they develop on the posterior surface of the petrous portion near its apex, and then proceed along this oblique plane medially toward the basillar process. Evidently the cerebellar hemispheres behind limit its growth backward. These conditions are immediately responsible for the particular dangers attending such tumors; for it is in the first place the pons and then the medulla oblongata, which the tumor in its growth not only compresses, but deforms and excavates.

In this patient conditions were otherwise. Here the tumor was found with the posterior pole in its outer half just beneath the dura; its median half was separated from the dura only by a thin layer of cerebellar substance. As a result it was immediately approachable upon opening the dura, while with tumors of the cerebello-pontine angle, the hemisphere of the same side must always be displaced medially before the posterior pole of the tumor comes into view. It is only when tumors of this sort are unusually large that they lie near the cerebellar dura, and even these, according to our experience, are always two centimeters removed from it.

These facts immediately suggested that the extirpated tumor had

taken its origin from the arachnoid on the side of the left cerebellar hemisphere. This was substantiated by the microscopical examination of Professor Östreich, who found the tumor to be a fibro-sarcoma arising from the membranes. But since at operation the dura was found everywhere normal, the point of origin could have been only the pia-arachnoid, and to be more exact, that covering the outer side of the left cerebellar hemisphere.

The following measurements give an idea of the large size of

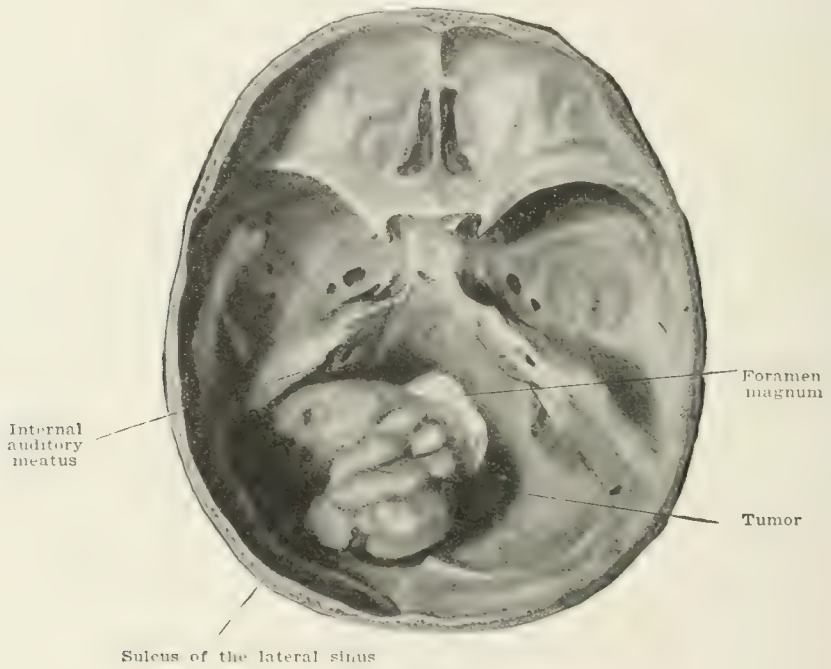


FIG. 598

Position of an unusually large arachnoidal tumor.

the tumor. After hardening it in 10 per cent. formalin and placing it in the base of a skull, in the position which it occupied in the living, it projected so as to cover more than half of the foramen magnum (Fig. 598). To the front it extended within 4 mm. of the internal meatus; but the basilar portion of the occipital bone was not touched. On its posterior surface it extended upward to the transverse sulcus; its upper surface projected 20 mm. beyond the upper edge of the petrous portion, and accordingly must have lifted up the tentorium to this extent.

After the operation was completed, the two packing strips were removed; the hemorrhage had practically ceased. The cavity, measured from the dural surface forward, was more than 5 cm. deep.

We sewed the dural flap in place above with a few catgut sutures, but on the left a slit was allowed to remain through which any free blood might find its way out. In order to prevent pressure, the bony plate was removed, as the thick cervical muscles represented a sufficient protection. The soft parts of the flap were sewed in without drainage.

The post-operative course was favorable. On the night after operation the patient rested quietly with the aid of a quarter grain of morphia. On the next day she was resting comfortably, in marked comparison to her earlier condition, in which, on account of the pain, she cried and threw herself about as if insane. The dull headache had completely disappeared. With comparatively slight subjective disturbances, the wound healed by first intention so that by June 8, she could leave the bed.

At the beginning of the following July her condition was as follows: The choked disc on both sides had disappeared; the patient saw well with the left eye, but with the right recognized objects only in the immediate vicinity; nevertheless, the vision here was also much improved, as before the operation she was practically blind. We were surprised to find that the hearing had completely returned in the left ear, as she heard whispers at a distance of 20 cm. The double vision had disappeared. There still persisted a nystagmus of both eyes, which was stronger on looking to the right, but there was no paralysis of the facial or hypoglossal nerves. The soft palate on the left seemed still to be paralyzed, as the uvula hung toward the right and the palatal arch dropped somewhat. There were no abnormalities demonstrable in the distribution of the trifacial.

The test of putting the finger to the nose demonstrated minimal ataxic ineptitude of the left hand, but there was no adiadochokinesis. The patellar reflex could readily be obtained. Movements of the head were entirely free as well as those of the arm and leg. In walking the patient still swayed slightly, but could go about alone.

The general condition was excellent and she returned home July 15. In September, 1913, we received satisfactory reports as regards her condition.

TUMOR OF THE CEREBELLAR SUBSTANCE AND OF THE VERMIS

Tumors are also found in the substance of the cerebellum as well as in the region of the vermis. The affected hemisphere may be

entirely replaced by the tumor, but sometimes we see in addition remnants of the normal cerebellar substance scattered through the mass, hemorrhagic areas, small cysts and occasionally large cysts, which may even represent the chief mass of the tumor. As a rule, in tumors of the cerebellum we have to do with sarcoma, angio-sarcoma, glio-sarcoma and fibro-sarcoma. We have frequently found at operation tumors which have taken their origin from the superior section of the vermis, and from this point have grown into one or both cerebellar hemispheres. To be sure, in tumors of large extent in the region of the vermis, we must often be satisfied with removing as much of the neoplasm as the condition of the patient will allow. That even in this manner we may attain results which approximate a cure, is shown by a ten-year-old boy in whom we removed as much as possible of a tumor of the vermis which involved both cerebellar hemispheres, and there has been no sign of recurrence during the two and one-half years which have intervened.

In extirpating a tumor of the cerebellum, we may sacrifice extensive portions of the cerebellar substance if necessary, and may indeed practically entirely remove one hemisphere. Technically this may usually be done even if only one hemisphere has been exposed. With careful retraction and displacement, as experience has taught us, we are in a position to cut away one-third to practically one-half. We have never seen any hemorrhage of note. If it is necessary to proceed further, the falx must be divided and the other half of the posterior fossa opened up. The more room one makes toward the normal side, the more approachable is the affected hemisphere.

Although we believe in the principle of radical extirpation of all affected tissue to a point well in the normal tissue, nevertheless we cannot agree to the principle of sacrificing a normal cerebellar hemisphere or its greater part, in order to more easily reach the posterior surface of the petrous portion for the removal of tumors of the auditory nerve. For this purpose a careful retraction in one or another direction, as described on p. 605, is much more satisfactory.

DIAGNOSTIC SECTION OF THE CEREBELLUM

For diagnostic purposes, on the other hand, we consider it not only permissible, but under certain circumstances necessary to incise the cerebellum. This may be readily done after the posterior

fossa is sufficiently exposed by drawing out the affected hemisphere, and according to a considerable personal experience it has never induced disturbing or threatening manifestations. In order to examine a large surface, a transverse division should be made direct from the outside toward the middle line, and to a depth of four cm. or more. The cut surfaces should be separated by a retractor. In one case in an eleven-year-old boy, in whom we made such an incision on both sides, at autopsy three years later no signs of a scar were found on slicing the brain.

A diagnostic incision is of importance on the ground that tumors which are deeply seated may be recognized neither by inspection, palpation, or fluctuation. In a case of Terrier's no tumor was found at an operation in which the surgeon had proceeded from the occipital brain to the cerebellar hemisphere by division of the tentorium. The patient died four months later with the wound healed; autopsy showed in the left cerebellar hemisphere a conglomerate tubercle the size of a small orange. The exposure and diagnostic incision of the cerebellum would have led to finding the tumor and made its removal possible, as we have seen repeatedly to be the case.

REMOVAL OF SOLITARY TUBERCLES FROM THE CEREBELLUM

Of tumors in the cerebellum the solitary tubercle, which occurs not infrequently in children, must be classified from a prognostic point of view as the most unfavorable. The symptoms which it arouses differ in no way from those of other solid tumors; except for the suspicion that the case is one of tuberculosis, it could never be recognized. If tuberculous foci exist in other parts of the body or if one finds in the upper lateral region of the neck, particularly on one side, marked enlargement of the cervical lymph nodes, the suspicion may be considered well grounded. The most unfavorable element in this condition is its frequent multiplicity. Tubercles may, for instance, exist in both cerebellar hemispheres, or in one hemisphere, and at the same time in the pons or the cerebrum; moreover, even after a successful extirpation there is danger of tuberculous meningitis arising.

A cuirassier, twenty years of age, of strong physical build, suffered for three months with vomiting, attacks of weakness, and marked headache, which occurred particularly on bending over and which always had its seat in the back of the head. There existed

also optic neuritis, nystagmus, paralysis of the right abducens, cerebellar ataxia with a tendency to fall to the right, disturbances of hearing on both sides, moderate stiffness of the neck and an increase of all tendon reflexes, together with the Oppenheim phenomenon. Oppenheim made the diagnosis of probable tumor formation in the right posterior fossa.

In the typical manner (see p. 593 and Plate 95) on May 6, 1909, we cut out an osteoplastic flap which measured above 10 cm., on the left and right 6, and at the base 8 cm. The dura over both hemispheres was tightly stretched, resembling two billiard balls, and showed no pulsation, nor was any pulsation to be seen in the dura which covered the medulla oblongata. Through a transverse incision of the ligaments at the base of the flap, the posterior arch of the atlas was exposed at its upper margin, and in that way the flap was completely mobilized. On the left side the dura was now found to be destroyed over an extent of 2 cm. just below the transverse sinus (Fig. 599, Plate 99), and in the opening a new growth was exposed which had a grayish-yellow color at the margin, and in the middle line was a bright yellow, with an absolutely dry surface.

It seemed at once to be a question of a solitary tubercle. The part of the tumor which projected, to about the size of half a cherry, was removed for microscopic examination. After this was removed there came away a small trace of cerebro-spinal fluid, a sure sign that the formation completely stopped up the opening in the dura. On account of the poor condition of the patient—the pulse, in spite of the slight loss of fluid, had increased to 120 and could hardly be felt at the wrist—the operation had to be interrupted. For protection of the inner surface of the bone and the surrounding tissue from contact with the new growth, this was covered with a layer of iodoform gauze, the end of which was carried out on the left side. Otherwise the flap was carefully sutured in place.

On May 15 the flap, which had healed in place without reaction, was freed up by blunt dissection with closed scissors, and after removal of the iodoform gauze and a blood clot which was adherent to the dura, it could be seen that the tubercle had projected a considerable distance through the dural opening. As the lesion now included almost the entire exposed posterior portion of the left cerebellum and extended upward as far as the transverse sinus,

Extirpation of two solitary tubercles, one from each hemisphere.

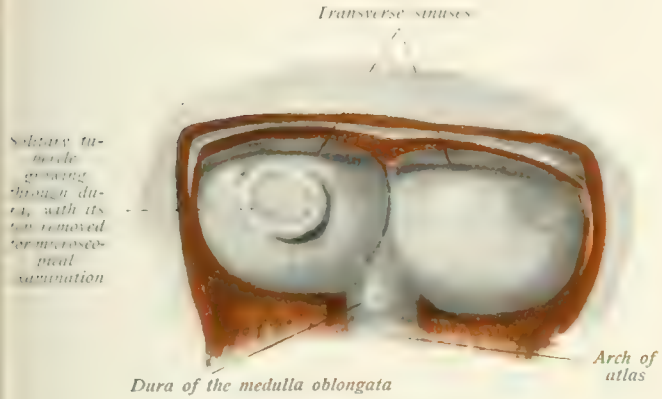

Transverse sinuses
Solitary tubercle growing through dura, with its top removed for craniocerebral summation
Arch of atlas
Dura of the medulla oblongata

Fig. 599. The dura over both hemispheres is exposed.

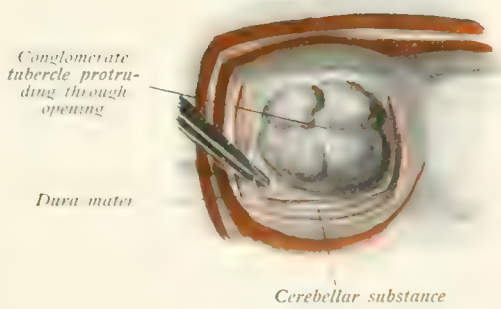


Fig. 600. A flap is made of the dura on the left side.

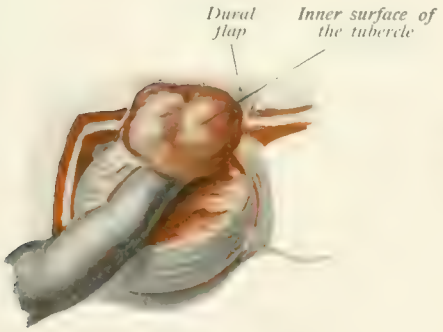


Fig. 601. Shelling out the tubercle on the left side.

Fig. 602. A flap is made of the dura on the right side.

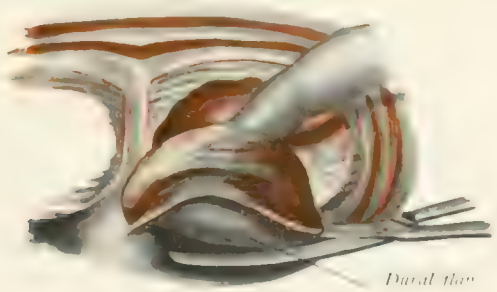


Fig. 603. Shelling out the tubercle on the right.

the ordinary incision below this sinus could not be undertaken, on account of the danger of injuring it. Accordingly, the transverse incision was made with a knife below the tubercle, so that the cerebellum lay exposed below (Fig. 600, Plate 99). Laterally, a vertical incision was made through the dura with scissors, and the same was done medially alongside the occipital sinus. Then the tumor was enucleated below with the finger, so that it remained in connection with the dura and still hung by a wide bridge of dura close to the transverse sinus (Fig. 601, Plate 99). The dura was divided just below the sinus and the extirpation completed.

The sinus was not injured. The rounded, somewhat heart-shaped solitary tubercle, was about the size of a walnut. The surface was irregular and showed several clefts. A careful examination showed that the extirpation had been a radical one. The tumor bed was held apart with two retractors, and to observation and palpation was completely normal.

The right hemisphere still covered with dura also showed no pulsation after extirpation of the lesion on the left. Exactly at the posterior pole which, in addition, seemed rather anemic and pale, it felt more tense and harder than at the periphery, which showed normal coloration of the dura. Here a typical flap was made with the base below, and turned down (Fig. 602, Plate 99). Then it was found that the pale middle portion of the dura was adherent to the surface of the cerebellum, and a rather large conglomerate tubercle like that on the left came into view.

This formation was enucleated from above with the finger (Fig. 603, Plate 99) and remained attached below by the dural flap. The extirpation was completed by dividing the dura transversely. After the enucleation normal pulsation was evident in both hemispheres, synchronous with respiration as well as the arterial pulse. The right tumor bed was likewise rendered visible by means of retractors, and examined with eye and finger. On both sides the tumor bed flattened out rapidly and on the right side it measured 38 by 35 mm., and on the left was somewhat smaller.

The difference in the conditions of the tumor on the right and left sides were as follows: On the left side the tubercle was adherent to the dura and had penetrated it. On the right, it was separated from it by a thin layer of normal brain substance and outside the clinical symptoms (abducens paralysis) it was evident through the lack of pulsation and the strong tension of the dura, which was

recognizable by the color even at the first stage of the operation.

Being tuberculous the wound cavity was stuffed with iodoform gauze and the wound sutured except for the space which gave exit for the gauze.

At the end of the operation the pulse was 120, its quality was much better than at the first stage, and the patient showed no collapse. On the next morning the pulse was 108, the temperature 100.4. As the dressing was saturated with fluid, the outside layer had to be renewed. On May 17, at the first complete change of dressing, on account of saturation, the wound showed no irritation. A certain amount of clear fluid came away along the drains. The temperature had fallen to normal, and the pulse was full and regular, 80 to 88.

On the sixth day following operation the iodoform gauze packing and most of the sutures were removed, the rest being removed four days later. The flow of fluid continued in decreasing quantity for seven days further, and then ceased.

Convalescence was uneventful. After nine days, except for motor weakness in the left leg, no pathological findings could be demonstrated; the patient could sit up in bed without swaying. The fundus showed no edema. Three weeks after operation the patient, feeling very well, got up out of bed. While up to this time the pulse and temperature were within normal limits, a few days later the temperature rose to 103, and the pulse to 112. Immediately the symptoms of a basillar meningitis became evident and the patient died six weeks after the operation.

Autopsy showed tuberculous meningitis over the entire base of the brain. Nowhere in the cerebrum or cerebellum, which were sectioned after hardening, were tuberculous foci to be found.

In other cases we have seen patients following a successful extirpation of solitary tubercle go to pieces as the result of phthisis or general miliary tuberculosis. In one child who came under our observation, there appeared the manifestations of a chronic acquired hydrocephalus. Since no focal symptoms were present at any time, no operative procedure was undertaken. Autopsy showed a marked hydrocephalus of all the ventricles, and the greater part of the right cerebellum studded with solitary tubercles; and there was one tubercle in the neighborhood of the hypophysis the size of a plum.

Extirpation of a tumor in the region of the vermis.

Falx cerebelli together with the occipital sinus double tied and divided
Large vessel
Dural flap turned down
Tumor envolving the vermis

Fig. 605. Exposure of the region of the vermis.

Fig. 606. The tumor is isolated.

Fig. 607. The wide exposure of the fourth ventricle following the extirpation.

EXPOSURE OF THE FOURTH VENTRICLE

In one case of tumor of the vermis, without having originally any such intention, we were forced to remove the roof of the fourth ventricle (posterior medullary velum), as the thin membrane had been entirely involved by the new growth. At the end of operation the rhomboid fossa lay entirely exposed in its characteristic form. To our surprise the patient ran an excellent course. The operative history is as follows:

A thirty-year-old unmarried woman had for three years suffered severe pains in the back of the head, left ear and left half of the face, as well as vomiting, vertigo, and buzzing in the ears. Her mind had suffered also. Examination by Oppenheim, May 2, 1911, showed the following conditions: bilateral choked disc, slight exophthalmos, hyperalgesia on the left side of the face, adiadochokinesis in the left arm and leg, pain on pressure over the occipital region. The condition of the corneal reflexes was not clear, but at any rate we were surprised to find that there was areflexia of the left cornea with the patient lying upon her right side. Moreover, with the eyes closed the patient swayed, but this showed something of a hysterical character, particularly as it was not present when her attention was diverted.

On the basis of these symptoms, it appeared that a tumor was present in the region of the left half of the cerebellum; but chronic serous meningitis could not with certainty be excluded.

On June 23, 1911, we opened the skull over the left posterior fossa, going over slightly onto the right side, that is to say, including the occipital crest. One week later the second stage of the operation was performed. After the osteoplastic flap was turned down, the left hemisphere was found to be under such strong tension that in incising the dura in the typical manner the cerebellum protruded with great force through the upper incision, tearing the arachnoid and pia. When the medial dural incision was made with scissors about five ounces of clear fluid shot out in a stream from the meshes of the arachnoid.

The dural flap was quickly completed and turned down. This brought to view a yellowish-red tumor situated in the superior region of the vermis, the surface of which resembled a blackberry (Fig. 605, Plate 100). In order to expose the tumor on all sides, the upper incision was enlarged, and the soft parts being freed up

from the occipital fossa on the right side, two centimeters more of bone were taken away. The dura covering the right cerebellar hemisphere was now incised above and below the transverse sinus and the falx cerebelli, together with the occipital sinus, was double-tied and divided. The tension had completely disappeared, and the brain no longer was in contact with the dura. The division of the falx cerebelli rendered the entire region of the vermis freely approachable.

Below, exactly in the middle line toward the medulla, the tumor covered with grayish-white arachnoid lay exposed for the extent of two centimeters; its height could not be exactly estimated since

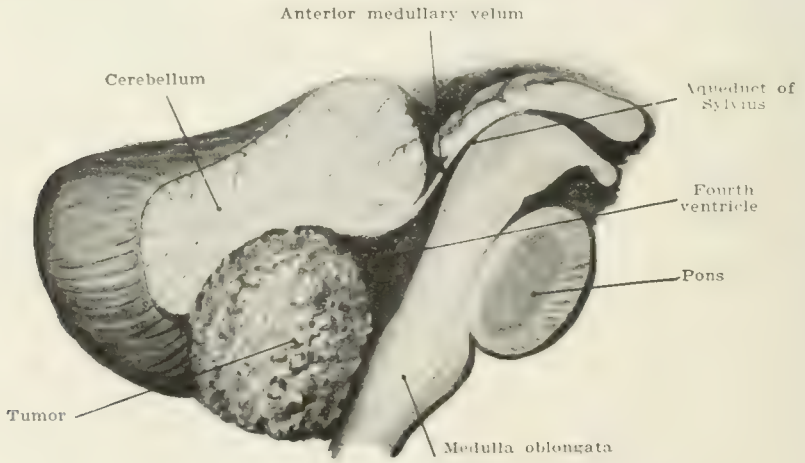


FIG. 604

Half-schematic representation of the location of the tumor.

it extended into the depths toward the medulla. After removal of the arachnoid, the attempt was made to free up the tumor from below, in order that the blood might not disturb the view, making use of small sponges held with anatomical forceps. In this process a surprisingly large tortuous vessel of a diameter of two centimeters came into view, apparently an artery (Fig. 605, Plate 100). This vessel was double-tied and divided by means of a Deschamps needle; thereupon still more fluid came out from the meshes of the arachnoid.

The tumor lay visible over its entire extent after the two cerebellar hemispheres had been drawn apart carefully with retractors (Fig. 606, Plate 100). It was carefully freed up in the manner described above, which could be readily done because it was well capsulated, and in consistency it was considerably firmer than the surrounding brain substance. The measurements of the extirpated tumor were

from above downward 40 mm., from before backward 25 mm., and in transverse diameter 30 mm. It was approximately the size of a large walnut.

The slight hemorrhage from the bed of the tumor ceased under light compression. After removal of the sponges, the fourth ventricle lay wide open so that one could recognize the rhomboid fossa in its characteristic form and could examine it clearly (Fig. 607, Plate 100). The tumor was located, therefore, in the roof of the fourth ventricle, that is to say, the posterior medullary velum was removed with it. The rhomboid fossa was carefully examined for remnants of the tumor, while the restiform bodies were carefully drawn apart with two small retractors. This showed that the tumor had been completely extirpated.

For protection and to serve as a covering for the rhomboid fossa, the two cerebellar hemispheres, which as yet were uninjured, together with the restiform bodies, were approximated in the middle line, so that only a small slit of the fourth ventricle remained visible. The small plate of bone, which originated in the left posterior fossa, was removed, and the dura replaced upward in the following manner. The divided falx cerebelli was first turned upward so that it completely covered the small exposed portion of the ventricle, and was fastened above temporarily with a clamp. In the same way the dural flaps on each side were held above, and with the head bent over backward, the flap composed of skin and muscle was sewed in place without drainage.

According to the microscopical examination, the tumor was a plexiform lymphangio-sarcoma.

In spite of the exposure of the rhomboid fossa, no respiratory or cardiac disturbances occurred after the second operation, either immediately or during convalescence. Once on the sixth day the evening temperature reached 100.8, just as it had also risen on the second evening after the first operation to 99.8, but otherwise during the ten days following operation it remained between 97.7 and 100.2, and then it became normal. There were mild variations in the pulse rate, but it never exceeded 100, and remained on the average between 80 and 90. The wound healed smoothly after the second operation. There was a slight flow of fluid during the first few days, so that the dressing had to be changed every day for the first four days. On the eighth day only the layer of gauze in contact with the skin was saturated, and accordingly, after removal of

most of the stitches, the dressing was allowed to remain undisturbed for three days. The remaining sutures were removed on the twelfth day.

On the fifteenth day it was noticed that the patient did not recognize her relatives, and displayed hallucinatory manifestations. Later, however, these psychic disturbances disappeared. In the left upper corner of the wound a prolapse of the brain was noticed about July 20, at first the size of a pea. By the 9th of August this protuberance had reached the size of a hazelnut, and at its apex a distinct orifice could be observed from which the liquor was coming away. If moderate pressure was exercised upon the skin flaps which had healed in place, the fluid was ejected in a stream. The flow was so great that the dressing had to be changed every other day. If it remained dry, as it occasionally did for two days, the headaches increased in severity and the patient began again to vomit morning and night. She then complained of alternating sensation of heat and cold over the entire body, of weakness of the left arm and leg, and the painful effect of light upon the eyes.

The temperature after July 22 showed fluctuations, but after August 6 it was again normal. The patient could sit up in bed alone without vertigo, in a few days exchanging the bed for a reclining chair for a half hour, but she still felt too weak to sit up longer. Examination by Oppenheim, on August 9, showed a trace of ataxia and tremor in the left hand as well as distinct adiadochokinesis, of less degree than formerly. The prominence of the papillæ could no longer be demonstrated through the ophthalmoscope, although the boundaries did not show up as sharply as formerly, particularly in the left eye. Her sensitiveness to light, which still continued, was surprising. On standing up, she had a strong feeling of vertigo, she became pale and complained of weakness; the respiration remained regular, the pulse was more rapid and of smaller volume, and it went from 80 to 112. A remarkable improvement was ushered in by a disappearance of the flow of fluid and a marked diminution in the hernia.

By November she showed practically no difficulty in walking. The menstruation had been re-established regularly, and the body weight had shown a steady increase. The young woman is now (1913) permanently well, and all objective manifestations have disappeared. There remains only a small protuberance at the site of operation, without tension and slightly fluctuating, which projects

Exposure of the fourth ventricle.

Fig. 608. The soft parts have been dissected away, and the middle portion of the posterior fossa removed.

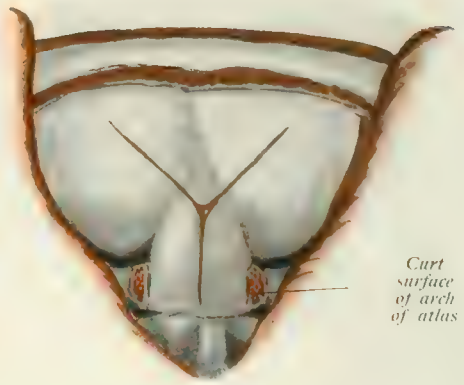
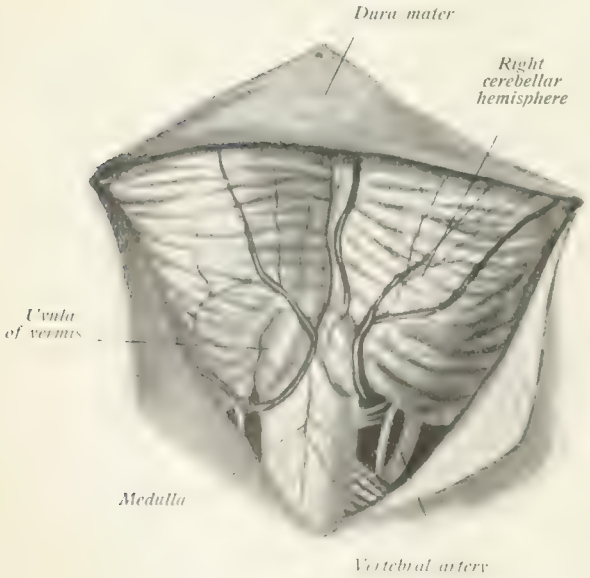


Fig. 609. Incision in dura mater.



. 610. Exposure of the vermis and medulla.

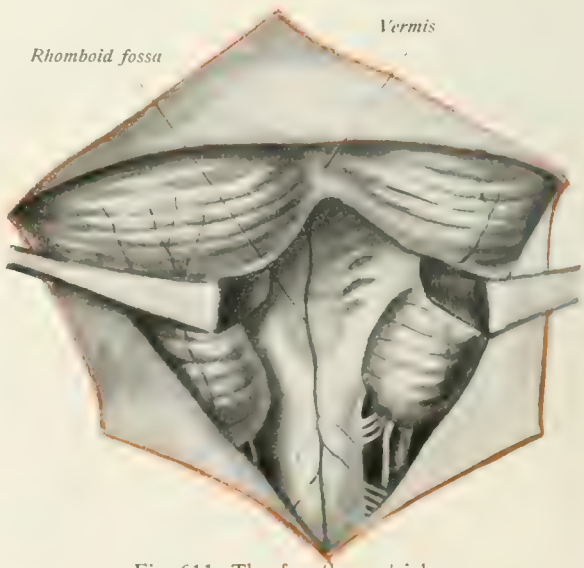


Fig. 611. The fourth ventricle.

one and one-half finger's breadth above the normal level of the scalp. This hernia has not changed in any fashion for more than a year.

The fact that the fourth ventricle may be widely opened without immediate danger to life is worthy of all the more interest when we consider the vital nerve elements which are located on the floor of the rhomboid fossa. The good results in the case just cited were dependent in our opinion upon the fact that after the extirpation was completed the rhomboid fossa was immediately covered in by bringing together over it the two cerebellar hemispheres and the dura. In this manner the secondary post-operative softening was prevented which even in its mildest form in this locality would undoubtedly have led to a fatal result.

In an earlier case in which on account of a similar tumor the aqueduct of Sylvius had to be opened, a small gauze strip was left in because of the not inconsiderable hemorrhage, and although the course was excellent during the first five days, on the seventh day after operation the boy died suddenly in a general convulsion, the packing having been removed the day before. Evidently in this case there had been softening as the result of the packing, and the irritation which it exerted upon the pyramids and the medulla oblongata led to the fatal convulsion. According to our experience, it must be again emphatically stated that operative brain and spinal cord wounds, trusting to a strictly maintained asepsis, should immediately be sewed up tightly by primary suture. In this way one can most assuredly prevent the danger of softening.

EXPOSURE OF THE MEDULLA OBLONGATA WITH OPENING OF THE FOURTH VENTRICLE

If one operates with the intention of exposing the medulla, as for instance in Brun's case of isolated cysticercus, another form of procedure must be carried out than that described on p. 631. An incision is made in the middle line from the external occipital protuberance down to the third cervical vertebra, dividing all the tissues down to bone. Care should be taken with regard to the atlanto-occipital ligament. At the upper end, a second incision should be made on each side at right angles with this one about eight centimeters long (Fig. 608, Plate 101). The muscles are dissected off on each side to the lower portion of the fossa, and the occipital bone

is removed to a sufficient extent to expose the middle half of both cerebellar hemispheres.

After the dura has been dissected off bluntly from the inner surface of the posterior arch of the atlas, this arch is cut on each side medially to the vertebral artery by means of the Krause laminectome (see the chapter on Surgery of the Spinal Cord). This being done, the segment of bone, approaching three centimeters in length, together with the posterior atlanto-occipital membrane which is still attached, is removed (Fig. 609, Plate 101).

We are now separated from the cerebellum and medulla only by the dura. In the lower half of its exposed surface the dura is divided in the middle line to the extent to which it covers the medulla. The incision above is continued over the convexity of the cerebellum on each side at an angle of about 130 degrees. The length of each of these incisions is about three cm. The incision through the dura is so disposed as not to injure the occipital sinus.

The dural flaps are now turned upward and to each side, exposing the uppermost portion of the spinal cord as well as the lower part of the cerebellum. On the cervical cord there may be recognized the posterior median fissure, the clava, the funiculus cuneatus, and the vagus and accessory nerves, and on the cerebellum there may be seen the convolutions of the hemispheres, the vermis and the flocculus. The vermis is now very carefully displaced upward without injuring it, and the two cerebellar hemispheres are drawn apart with blunt retractors, thus opening the fourth ventricle.

EXPOSURE OF THE PONS AND THE CORPORA QUADRIGEMINA

The pons Varolii rests upon the upper surface of the basillar portion of the occipital bone. Its lower surface may, therefore, be reached by trephining this bony process. A transverse detachment of the soft palate from the posterior margin of the hard palate, which in case of necessity the removal of its margin, together with a strong retraction backward, the patient being anesthetized by the intratracheal or intralaryngeal method, affords ample room for this procedure. But at the same time there is to be found on the anterior surface of the pons the large basillar artery with numerous lateral branches going off at right angles, and in addition many veins. The space, narrow in itself, becomes, therefore, still more restricted, and hardly anything more than simple puncture, or in any case opening of a cyst followed by drainage can be accomplished through the

base of the skull, wholly apart from the fact that asepsis cannot be practised in this region.

Yet this method is worthy of mention for another reason. It seems plausible that by this route collections of pus at the base of the brain may be approached, and although as yet no definite indication has been determined upon for this procedure, nevertheless, as brain surgery is rapidly advancing, it may find its place in the future. Up to the present time, tumors of the pons have been considered as not amenable to surgical treatment. To be sure we have in one case attempted to approach the pons from the side and behind in order to open a suspected cyst. Although the cyst was not found, the extensive operation did no harm to the patient, and on the contrary it benefited her through the resulting decompression.

After making an osteoplastic opening, including both halves of the posterior fossa, double-tying and dividing the falx cerebelli, together with the occipital sinus, the two cerebellar hemispheres were exposed to the widest extent. The patient being in a sitting posture and with the head bent over slightly backward, the cerebellar hemispheres gradually came down to a considerable extent into the wound, so that their posterior surface was practically level with the skin.

After one large and two small veins which lay close together running up from the surface of the vermis to the straight sinus, were tied and divided, and the tentorium cerebelli was elevated with a brain spatula, the upper portion of the vermis lay exposed in its entire extent to a point almost as far forward as the corpora quadrigemina.

The posterior surface of the left petrous portion of the temporal bone was now rendered approachable by carefully displacing the left cerebellum medially with the retractor. Immediately the auditory and facial nerves came into view. Then it was possible to proceed further medially along the upper edge of the petrous portion close to the origin of the anterior margin of the tentorium cerebelli, until the brachia conjunctiva were visible over a good centimeter. Thereupon one could very clearly see the medially situated free crescentic margin of the tentorium cerebelli. The pons, which lay just under the brachia conjunctiva, could be felt with the finger, but it showed the same consistency as normal cerebellar substance. Finally, a long cannula was introduced through the brachium conjunctivum into the pons, and ½ c.c. of sero-hemorrhagic fluid was aspirated.

The region of the *corpora quadrigemina* is approachable by the same posture and operative technique, as it lies in front of the superior section of the vermis. Thus, for instance, in a ten-year-old boy, in whom Oppenheim made the diagnosis of a neoplasm in the region of the corpora quadrigemina and the third ventricle, we came upon a lobulated tumor the size of a plum upon the posterior pole, 54 millimeters in front of the dura of the cerebellum, and on account of its firm consistency, in spite of the depth at which it lay from the surface, succeeded in shelling it out completely with a blunt medium-sized spoon. After controlling the moderate venous hemorrhage by gauze compression one could see in the tumor bed, 20 millimeters of which was still visible in the middle line after the structures had fallen together over it, the pineal body and on both sides the posterior tubercle (pulvinar) of the optic thalamus, the free lying internal cerebral vein, as well as the triangular incisure of the tentorium cerebelli. The wound healed and the boy improved progressively, so that five weeks after operation he was out of danger.*

CYSTS IN THE POSTERIOR FOSSA

Of all the operations in the posterior fossa, those for the treatment of cysts have given the best results. Moreover, the clinical and morphological conception of cyst formation has been well worked up. The favorable prognosis applies particularly to true cyst of the cerebellum and to the special class which are known as arachnoidal cysts. Cystic tumors on the other hand belong particularly to the infiltrating sarcoma, and have a less favorable prognosis than the circumscribed neoplasms.

To the *traumatic cysts* belong the extensive tumors which rise in the tissues of the cerebellum following operative procedures, which as they increase in size cause annoying disturbances to the patient. We have frequently observed these to form if the cerebellum has been torn or squeezed at an earlier operation for removal of a tumor, or if it has been incised horizontally for diagnostic purposes. Replacing a portion or the whole of a cerebellar hemisphere, one may find a hollow sphere surrounded by a layer of white connective tissue, containing a jelly-like material, with thin partitions and strands running across it. After opening the cyst wall, the watery contents run out and the white stringy septa which cross the cyst

* Krause, Berliner medizinische Gesellschaft, Meeting of November 26, 1913.

and represent the brain tissue which has degenerated, remain. If no tumor tissue is present, that is to say if there is no recurrence to represent the cause of the patient's symptoms, the entire posterior cyst wall is removed, in so far as this can be done without severe

FIG. 612

Cyst in the vermis, extending into the right cerebellar hemisphere; sagittal section through vermis; seen from behind. Three-quarters natural size.

injury to the cerebellar substance, and the skin flap is sewn in its place.

In cysts in the cerebrum as well as in the cerebellum, one can prevent reaccumulation of fluid to the best advantage by first making a wide opening, removing a considerable section of the superficial wall of the cyst, and then turning the pediculated flap of dura into the cavity. In this manner natural drainage results, which creates favorable condition for obliteration of the cavity.

Fig. 612 represents a true glia cyst in the vermis of a twenty-six-year-old man, who died as the result of acute respiratory paralysis before he came to operation.

ARACHNITIC CYSTS

occur in the periphery of the cerebellum, and as they increase in size they may simulate to a marked degree a solid tumor. The watery contents of such arachnoidal cysts may be seen shimmering through the thin wall. In many places a fine whitish fibrous connective tissue is likely to reinforce the transparent arachnoid. That inflammatory processes in the soft membranes may cause a fusion of the layers of the arachnoid and result in a collection of cerebro-spinal fluid may be inferred by scar changes and adhesions found in other portions of the pia and arachnoid, as well as the occasional flat adhesions between the upper surface of the cerebellum and the lower aspect of the tentorium which we have seen. After opening the cyst wide and destroying the adhesions, we have observed complete recovery lasting over many years.

Concerning *arachnoidal cisterns,* particularly the *great cerebello-medullary cistern,* which extends from the basal surface of the cerebral hemisphere to the dorsal aspect of the medulla oblongata, mention is simply made here for the sake of completeness. For further discussion of this condition see Krause, Surgery of the Brain (Rebman, 1912, Vol. II, p. 726).

TUMOR CYSTS

Behind every encapsulated chronic arachnitis as well as behind every cyst of the cerebellar substance, a tumor may be hidden. Accordingly, if a cyst be found, careful inspection and palpation of the parts should always be carried out, as well as diagnostic puncture and, in case of necessity, horizontal incision of the cerebellum. In spite of the greatest care, a tumor formation in the vermis or in the neighborhood of the aqueduct of Sylvius may escape detection by the operator. In such cases cerebro-spinal fluid will again collect very rapidly in the operative field after the operation.

Cystic tumors of the cerebellar substance proper are not infrequent. The symptoms resemble those of solid tumors.

Simple serous cysts can only be recognized as such when the most minute examination of the cyst wall shows no evidence of tumor tissue. Idiopathic cysts occur without tumor formation. This is

definitely substantiated in our experience with cerebellar cysts which have remained healed for years, in which it must be accepted that neoplasm could not have been an element. The fluid as a rule is amber colored, at times somewhat paler, resembling serum, and occasionally of a darker tinge. On account of its large content of albumin, on cooling it becomes transformed into a jelly-like mass. The proportion of albumin, however, has no diagnostic value with reference to the benignity of the cyst or to its relationship with neoplasm. After opening a cerebellar cyst and evacuating its contents, the walls may collapse so that it may be difficult or even impossible to separate the walls and recreate the cavity.

In many cases differentiation may be made from the structure of the cyst wall or by its surroundings. Either areas suspicious of neoplasm are present in the contiguous portions of the brain tissue, or inequalities in consistency may be recognized on palpation. Firmness of tissue speaks for neoplasm. Softness and smoothness of the walls are more frequent in small cysts or diverticulæ of the ventricle. In tumor cyst the wall is rougher, and moreover in many places fresh or old hemorrhage may frequently be recognized. In one of our cases, the otherwise smooth but opaque cyst wall was distinguished by an ochre yellow coloration, which made it stand out very plainly from the surrounding cerebellum.

TUMORLIKE FORMATIONS

As has already been shown by the example given on p. 627 ff., conglomerate solitary tubercles and gumma must be considered as tumors, and in case of necessity be treated operatively; they give rise to the same symptoms. With gumma specific treatment usually fails, while the Jacksonian attacks which occur in syphilitic meningitis of the convexity of the cerebrum, frequently yields to proper medication.

Parasitic cyst formations, such as echinococcus, may, of course, show the same manifestations. Like tumors, they limit the space within the cranium, and cause pressure upon the neighboring portions of the brain.

Even with the extirpation of a brain tumor successfully completed, a satisfactory technical result may be spoiled by progressive softening in the region surrounding the operative field, which may lead to death. Accordingly, in case the operative wounds heal and no

recurrence develops, but the paralysis does not improve in any manner, it is to be recorded as a failure, just as if the extirpation of the tumor had not succeeded.

THE DECOMPRESSION OPERATION

In every operation on a brain tumor, we must be prepared for the fact that after making an extensive opening in the skull and dura the tumor may not be found, or that its enucleation is seen to be impossible. The later contingency occurs more frequently in subcortical than in cortical tumors. In either case nothing more can be done than to close up the opening again by careful suture. But even after such apparently useless operations we find considerable improvement. By a gradual protrusion at the site of the osteoplastic opening, the rigidity of the cranial walls is compensated for, the high intracranial tension diminishes or disappears altogether, and with it disappear the more disturbing of the symptoms. These favorable results have led to the formation of an artificial brain hernia in tumors of the brain which cannot be localized, an operation which is called decompression.

As regards the technique of this palliative operation, it differs but slightly from the methods already described. Horsley removes the bone over a large area, but this does not agree with the method of osteoplastic resection employed and recommended strongly by Krause. In order to obtain an effective release of tension, the opening in the skull must be made larger than the bone plate, and accordingly on all four sides of the opening a strip of bone, one to two cm. wide, is removed with the rongeurs after the periosteum has been scraped back.

Krause recommends the preservation of the bone plate always on the following grounds. As the result of the generally increased cerebral tension the plate is immediately protruded so far that there is no basis whatever for anxiety lest bony or dense connective tissue adhesions arise. The skin, which has been exactly approximated, stretches as the result of its great elasticity to correspond to the protrusion. The bone plate prevents shrinkage of the osteoplastic flap: if the bone is sacrificed, the resulting shrinkage of the soft parts which are left may cause a marked diminution in the size of the flap. This happens particularly if all the sutures do not hold, and wherever this takes place a prolapse of the brain occurs.

The dura mater should be opened over a considerable extent.

Protrusion of the brain, occurring immediately after incision of the dura, generally causes a good deal of trouble. In some instances the protrusion may be so great that the pia, arachnoid and cortex tear on the sharp edges of dura and bone, causing severe disturbances of function, and at times such injuries give rise to hemorrhage in the brain substance with subsequent edema and extensive prolapse. In order to obviate this as much as possible, the same technique may be used as that for opening of an abscess (see p. 665). The dural flap should be made considerably smaller than the opening in the bone, and at the four corners the margin of dura is cut obliquely to the corners of the bony opening with blunt scissors, so as to form four narrow dural flaps, which are turned up over the corresponding edges of the bone so as to effectively cover them.

By the technique described, we also fulfil the requirement that after the osteoplastic flap has been sewn back into place, which should be done without drainage and with the greatest care, the skin scar will not correspond exactly with the edge of the bony opening. If the skin flap is made on each side several millimeters larger than the bony plate, then the suture line lies almost exactly half-way between the margins of the bony openings and the edge of the bony plate. The basal dural flap covers the brain and the soft membranes, and prevents these from coming into direct contact with the inner table of the bony flap.

In order to obtain greater assurance against tearing of the suture line, which is quite likely to happen as the brain hernia grows, the base of the osteoplastic flap may be directed to one side as usual, and that of the dural flap in the opposite direction. If the skin flap is lifted up as the intracranial pressure increases, and if separation occurs at the edge opposite the base, the wide dural surface at this point prevents extrusion of the brain.

Harvey Cushing prefers to open the cranial cavity in the temporal region, without preserving the bone. This region overlies a comparatively mute area of the cortex. He depends upon the well-developed temporal muscle, whose fibers he splits but does not divide, to prevent bulging of the brain substance.

This method of *subtemporal decompression* is carried out as follows: An incision is made through the scalp over the middle of the temporal fossa, preferably on the right side, running parallel to the fibers of the temporal muscle. (Formerly he made a curved incision through the scalp, parallel to and one centimeter below the origin

of the temporal muscle. He has discarded this, however, for the vertical incision, which gives more room, can be lengthened for exploratory purposes, and which leaves a practically unnoticeable scar.) Skin and superficial fascia are divided, and the tense temporal fascia exposed. This and the muscle lying beneath it are split about in their middle by means of an incision down to periosteum

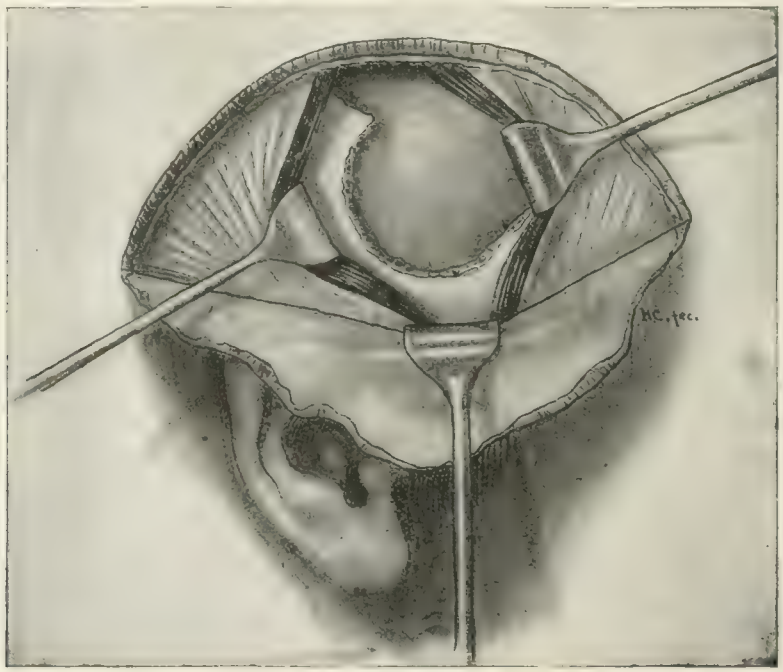


FIG. 613

Cushing's subtemporal decompression, partly completed. The bone is rongeured away for some distance under the retracted muscle flap. The incision through the skin and galea is now made vertical instead of curved, as shown in this picture. (Cushing—from Keen's Surgery.)

which runs exactly in the direction of the muscle fibers, that is to say, obliquely forward and downward.

The anterior and posterior margins of the temporal fascia and muscle are now retracted as strongly as possible and lifted away from the skull, thus enabling one to scrape away the periosteum from the bone over as great an extent as possible, and to remove the bone of the temporal fossa over an area extending vertically five or six cm., and horizontally eight or ten. The bone is broken away with flat-bladed rongeurs, taking particular pains not to injure the middle meningeal artery (see Fig. 613). The dura must be very carefully freed up.

After the opening has been completed, Cushing opens the dura and cuts it away to near the bony margin, first tying off the middle meningeal artery. The bluntly separated muscle fibers and temporal fascia are carefully sewed with buried interrupted sutures without drainage, and then the superficial fascia and skin are closed in layers without drainage.

At times the brain projects so strongly that it is impossible to reunite the divided temporal muscle. In this case the sutures, which can be tied only under a considerable tension, cut directly into the brain cortex; the same thing may also be the case with the temporal fascia. But if only the skin can be firmly united, the advantages of Cushing's technique are lost.

The immediate danger of the decompression operation cannot be considered great, and the operation, like tracheotomy, represents under certain circumstances a life-saving procedure. We have repeatedly operated upon patients representing the most severe cases of intracranial pressure with a pulse as low as 32, and in a state of deep somnolence, so that the operation could be carried out without anesthesia. Frequently we have found that the pulse went up to normal, the patient regained complete consciousness, and life was restored. Moreover, we have seen occasional cases in which permanent cure resulted from this simple operation alone. In such cases we are dealing with a remarkable class of which so far we know little, acute swelling of the brain and subacute encephalitis.

Frequently in tumors we observe the favorable influence of the operation upon headaches, vomiting and visual disturbances. Moreover, convulsions often decrease somewhat in severity or frequency, and the sensation of vertigo becomes less intense. Horsley advises that the operation be performed as soon as optic neuritis is recognized.

According to our experience the measure is of less value in cases of rapidly growing tumors or those near the surface of the cortex. Diffuse glioma and glio-sarcoma, involving wide areas on the cortex and medulla, are particularly unfavorable. The decompression operation is likely to give only temporary relief in such cases; soon as a result of the continued growth of the tumor the osteoplastic flap, particularly if it has healed in, is lifted high on the mass, the suture line is drawn apart or the fresh scar destroyed. Rapidly the tumor mass presses outward on all sides, and it is impossible by any means to keep it within bounds.

But if, on the other hand, the tumor is located deep in the brain substance, the hernia may grow to considerable size without causing rupture of the scar, which is a great advantage. To be sure, it happens all too frequently that the normal sections of the brain which are pressed out in the hernia suffer from the marked displacement and tearing, from the compression and edema, and when very sensitive regions are involved, such as the central region of the cortex, marked and even serious disturbances of function extending far into the surrounding territory may be caused by the cerebral hernia itself.

The decompression must be performed over the cerebrum or the cerebellum, according as the tumor has its probable location in one or the other section of the brain, above or below the tentorium.

As regards the cerebrum the operation is always done upon the side of the lesion, where this can definitely be made out. Otherwise in right-handed persons the opening should be made over the right hemisphere of the cerebrum, by choice in the parietal region behind the posterior central gyrus, that is to say, over the least important section of the cortex.

The right temporal region should also be considered in this connection. But if the Cushing method is employed, important cortical areas in this region may indirectly become involved. As has been shown by autopsy, the bony opening exposed particularly the convolutions which are located below the fossa of Sylvius, but always as well the lowermost section of the central region, that is to say, the centers for the tongue, lower jaw, and the lower portion of the facial distribution. For that reason, Cushing has misgivings, in operating bilaterally by his method, which seems to him to be rarely necessary, over the removal of the dura on both sides, lest the gradually protruding cortex of both hemispheres be exposed to severe injury.

If a cerebellar tumor is suspected, without its being possible to determine upon which side it occurs, both sides should be exposed; but since the thick muscle layer of the neck offers sufficient protection, the bone in this locality may be sacrificed. In cases in which a hydrocephalus may be confused with a cerebellar tumor, opening of the posterior fossa and of the dura may be of great assistance. But the decompression operation carried out, particularly over the cerebellum, without regard to the probable seat of the neoplasm, is not justifiable. For we cannot be convinced that

in tumors of the cerebrum, even when located in the posterior halves of the hemispheres, enough relief of tension may be obtained by opening over the cerebellum, because the tentorium is unyielding and is stretched tightly between the posterior fossa and the cerebrum.

In turret-shaped skulls with increased intracranial pressure the decompression operation is to be considered. Schloffer, in order to improve the often very severe visual disturbances, has freed the optic nerve from its adherent position in and behind the optic canal, by removing the roof of this bony canal with fine chisel and rongeurs. The approach is by way of an osteoplastic opening similar to that described on p. 575 ff.

DIAGNOSTIC AND THERAPEUTIC PUNCTURE OF THE BRAIN

To Neisser and Pollack* belongs the credit of having developed in a scientific manner the technique of brain puncture; the history and literature of the subject will be found in their work. It is proper to state, however, that Middeldorpf introduced akidopeirastik in 1856, and first employed it in encephalocele, cephalhematoma and hydrocephalus.

Neisser and Pollack have indicated, according to the Kocher scheme for cranio-cerebral topography, the points from which one can with the most assurance undertake the puncture of the various individual sections of the brain, without injuring the middle meningeal artery and its branches. Their illustration is given in Fig. 614.

The two points for the frontal lobes (F1 and F2) are located vertically above the middle of the supra-orbital margin, at a distance of 4 and 8 cm. respectively.

For the central convolutions three points are designated (C1, C2, and C3). First the course of the central sulcus is laid out according to Krönlein, or the precentral sulcus is laid out with Kocher's kyrtometer, which line at the same time corresponds to the anterior branch of the middle meningeal artery; its posterior branch, according to Pfeifer, ordinarily corresponds in its course fairly closely to the naso-lambdoid line. As the width of the anterior central gyrus is from 18 to 20 mm., one should stay about one cm. away from either of the two central lines. C1 corresponds to the center for the upper extremity and C3 to that for

* Die Hirnpunktion: Mitt. aus d. Grenzgeb. d. Med. u. Chir., 1901, Vol. XIII.

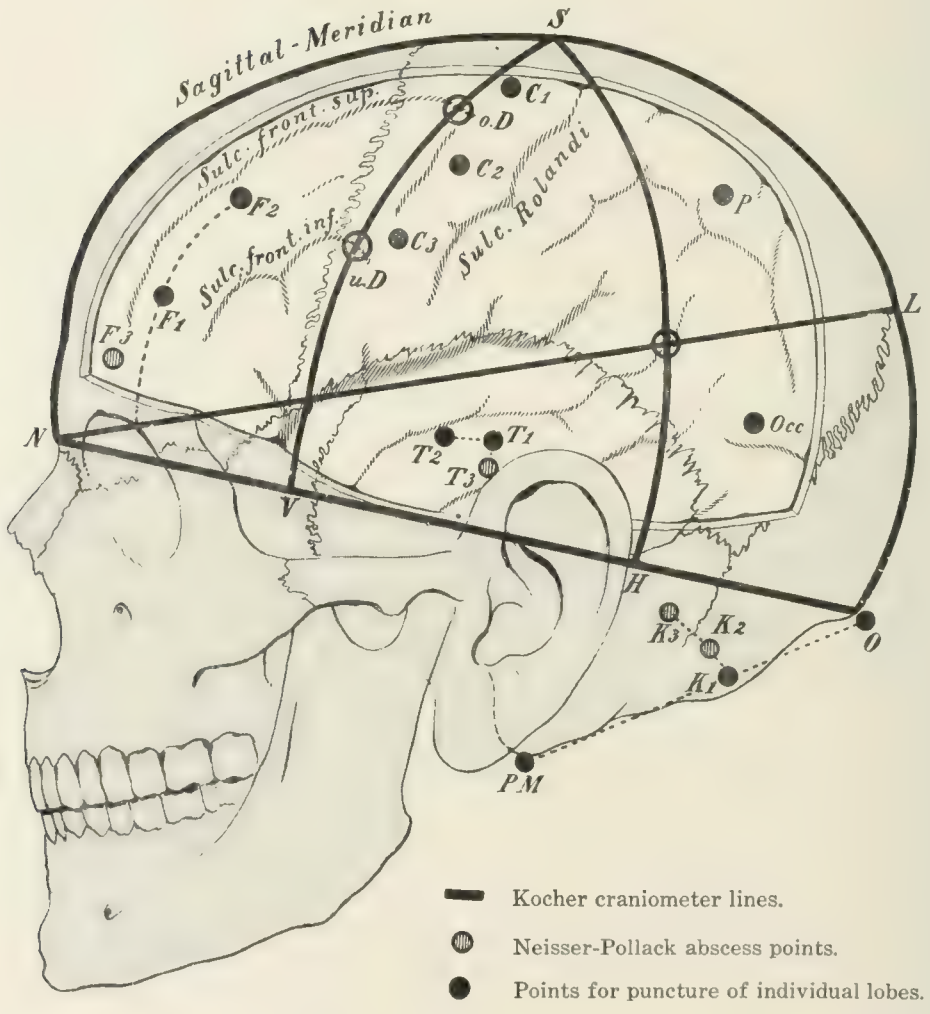


FIG. 614

Scheme for brain puncture, from Neisser and Pollack, Die Hirnpunktion (Mitteilungen a.d. Grenzgebieten, 1904). The points are shown in their relation to the cranio-cerebral topographic lines of Kocher.

S = parietal point, half way between N (root of nose) and O (external occipital protuberance).
NVHO = equatorial or basal line.
NSO = sagittal meridian.
SV = anterior oblique meridian, precentral line.
SH = posterior oblique meridian, linea limitans.
NL = naso-lambdoid line; the portion between the two oblique meridians is called by Kocher, "Temporal Line I."
o.D = upper trisection point of precentral sulcus.
u.D = lower trisection point of precentral sulcus.
PM = tip of mastoid.

the facial region. No puncture is made lower than this, because it would approach too closely to the fissure of Sylvius, and might injure the good-sized artery which runs here. Broca's convolution may be located in the obtuse angle made by the anterior oblique meridian (S. V.) and the naso-lambdoid line (N. L.).

For puncture of either the parietal or occipital lobe, a point located about at their middle (P and Occ) is chosen. From either point the lateral ventricle is met at a depth of about two cm. from the surface of the brain.

The two points for the temporal lobes are T1 and T2. The first lies from 1 to 1½ cm. above the origin of the shell of the ear and corresponds to the center of the lobe; the other (T2) is located on the upper horizontal (see Fig. 491, p. 493) 1½ cm. further forward. From this point one reaches the lower horn of the ventricle at a depth of about 3 cm.

For puncture of the cerebellum, we make use of point K1 in the middle of the line which joins the external occipital protuberance (O) with the tip of the mastoid process (P N).

PUNCTURE OF BRAIN ABSCESS

For the puncture of abscesses located in the typical situations in the brain, Neisser and Pollack give the following points.

Point T3 for abscess in the temporal lobe lies one-half to three-quarters cm. vertically above the upper origin of the shell of the ear. As from this same point the inferior horn of the ventricle is reached, one should proceed very gradually into the depths, making a continuous suction with the syringe. In large abscesses the puncture points T1 and T2 may also be considered.

For otitic abscesses in the cerebellum the best point is K2, which lies half way between K1, which has already been described, and a new point K3. The latter is situated at the posterior margin of the mastoid process, at its uppermost palpable point. Point K2 corresponds to the angle made by the sigmoid (lateral) sinus, but it is far enough removed from its two limbs to avoid injuring it. The puncture must be made at right angles to the bony surface. This precaution applies also to point K1 for puncture of the cerebellum, but not for K3: here the cannula should be directed slightly forward and downward toward the face and the base of the skull, then in the knee of the sigmoid sinus the cannula comes

in contact with the lateral and most anterior section of the cerebellum.

Large abscesses may also be reached through point K1. Abscesses of nasal origin may be punctured through F1; but since the most anterior pole of the frontal lobe lies at F3, somewhat medially and below F1, this point is more to be recommended, if one has no hesitation lest in penetrating the forehead a large frontal sinus be opened up. At this point a second sense of resistance felt in passing the needle, which represents the posterior wall of the cavity, should lead to a clear recognition of the sinus.

All other abscesses located in the medullary portion of the cerebrum are reached through the puncture points given for the respective lobes.

EXTRA-DURAL HEMATOMATA

These, if they arise from branches of the middle meningeal artery, are met with at the two points B and K1, indicated by Krönlein on Fig. 491, p. 493. In order not to injure the vessels, the skull should be drilled a little behind the point. Hematoma of the posterior fossa, which is less frequently met with, may be reached through the Neisser point K1.

It is important from the point of view of brain puncture to know exactly the thickness of the tissues covering the brain, the membranes and the spaces filled with cerebro-spinal fluid included. It must also be remembered that the thickness of the bony covering varies not only with the various regions, but also with the age, sex, and the individual. The scalp, calvarium, and membranes together possess in the adult an average thickness of one and one-half to two centimeters; in the temporal region the bone is considerably thinner, but on the other hand the powerful temporal muscle with its fascia and its interfascial fat bodies must be included in the brain coverings. In the frontal region one must reckon with varying thicknesses and with the often extensive frontal sinus; we have seen it twice extend into the temporal region and have opened it at this point in extirpation of the Gasserian ganglion.

In all those places where danger of meeting a sinus exists, after a linear incision has been made and the periosteum has been scraped away from the bone, the opening through the bone is made with a burr drill, and the exposed dura is then punctured.

As regards technique, the operative field having been prepared,

the puncture is usually done without general anesthesia. As a local anesthetic for the soft parts the ethyl chlorid spray, or subcutaneous injection of novocain-suprarenin solution may be employed. Without a previous skin incision a hole is made with a strong drill of a diameter of two millimeters of the type shown in Fig. 615, through soft parts down to bone, and by using a little care, one can very easily recognize when the external plate has been penetrated and the internal plate is reached. Just as in trephining, we always employ for this purpose a hand drill. In order to drill rapidly without fear of puncturing the dura and even of injuring the brain, the metal shoulder is attached to the drill shank one or one and one-half cm. from the point, and the hole is made at once to this depth. Then the drill is withdrawn, and while the assistant presses the soft parts on either side of the skull tightly against the bone, a cannula graduated in centimeters is introduced.

In some cases it is advantageous to displace the soft parts slightly

Fig. 615—Drill.

before making the drill hole, so that the drill hole will not correspond to the skin opening. The depth at which the needle, which in case of necessity is supplied with a mandrin, shall be introduced into the brain, depends upon the affection which it is intended to relieve. We use a cannula which is oblique at the point, with a diameter not to exceed 1½ mm., but with the thinnest possible wall, in order that by aspirating the tiny plug of brain substance within the needle, it may afford sufficient material for microscopic examination. At first the cannula is introduced through the drill hole into the brain to see whether any fluid comes out. If no fluid appears, suction is applied. Pfeifer recommends platinum-iridium needles because they do not rust.

For aspiration purposes, a carefully made ground-glass syringe with a metal piston is satisfactory. A small size syringe with a capacity of 1 cm. is very easy to handle, but larger ones up to 5 c.c. are also satisfactory. With the small size syringe in order to get a cylinder of brain substance, the barrel must be disconnected and reapplied several times, leaving the needle in place. With the larger size, a single slow withdrawal of the piston suffices.

In spite of careful suction a brain cylinder cannot always be obtained; this is true for large as well as small syringes. But if in such cases, with the piston drawn back, one removes the syringe with the attached needle quickly from the brain, as a rule the cylinder is drawn out on the tip of the needle. In order to remove the cylinder intact from within the needle, the barrel is filled with sterile salt solution and the specimen expelled by pushing down on the piston.

DANGERS OF BRAIN PUNCTURE

The branches of the middle meningeal artery, the cerebral arteries in general and the larger sinuses as well, may ordinarily be readily avoided by the needle, because their course is, as a rule, regular and definite. But any one who has frequently exposed the surface of the brain will agree that the course and size of the pial veins cannot be depended upon. They often occur in large size in sulci of little importance, but they may be very small in the central sulcus. Moreover, they have thin walls and may readily be injured. If the brain and the intracranial pressure are normal, they naturally possess a small lumen, but when the brain pressure increases, they may dilate to a considerable degree, and in that case their injury may involve serious results. Even the finest needle will not prevent trouble. We have in a case of brain tumor seen the dural veins reach the diameter of a lead pencil. Moreover arteries and veins may be so considerably displaced by the growth of tumors that anatomical localization is impossible. In the punctures which we have performed, disturbing hemorrhage has been observed several times.

The danger of infection must not be disregarded. Infection from without may be avoided with assurance, but not so that arising from intracranial foci. For this reason we advise that when brain abscess is suspected, a diagnostic puncture be done first, after the dura has been widely opened in the form of a flap. Then the field may be packed off with assurance by introducing iodoform gauze strips between the surface of the brain and the dura (for more detail see p. 665).

Besides infection through pus, the possibility exists that one may penetrate with the needle through a tumor into the sound brain tissue behind, and give rise to propagation of the particles of tumor tissue. Generally speaking, this disadvantage may be prevented

by proceeding from layer to layer in the manner recommended by Neisser.

Other disagreeable manifestations may be aroused by brain puncture which we can only mention here. In order to forestall danger so far as possible, the method should only be employed after all the preparations have been made for an osteoplastic operation, in order that in case of necessity this operation can be immediately performed.

Brain puncture represents a perfection of our methods of investigation. But it should only be carried out when all the other diagnostic aids have been of no assistance. Oppenheim has particularly stated that in some cases of hemianopsia, brain puncture alone can determine whether the focus of disease is to be sought in the temporal, occipital or parietal lobe. The experienced diagnostician, who in many cases is able to localize a tumor with great certainty, will find less frequent use for brain puncture than the unskilled.

VENTRICULAR PUNCTURE: PUNCTURE OF THE LATERAL VENTRICLE

Puncture plays an important rôle in the diagnosis and treatment of internal hydrocephalus.

For puncture of the lateral ventricle, the chief diameter of which runs in a sagittal plane, Kocher prefers such points as correspond to this direction. According to his experience, the most favorable place for puncture lies above in front of the bregma (anterior fontanelle). At a point 2 cm., or better still 3 cm., from the middle line, to avoid injury of the longitudinal sinus, he introduces the needle downward and backward; at a depth of 5 or 6 cm. the ventricle distended with fluid is reached. Kocher has carried out drainage also in this manner. According to his point of view, one can most readily prevent injury of the opposite wall of the ventricle if the tube is introduced only into the upper portion of the cavity, and is fixed to prevent its working farther in. Von Bergmann, on the other hand, punctures the lateral ventricle through the forehead by drilling the skull just over and slightly to the medial side of the frontal eminence, and introduces a long needle into the brain backward, slightly inward and downward, until fluid flows through the needle.

As regards lateral puncture, Keen has selected a point 3 cm. behind and 3 cm. above the external auditory meatus. In the

direction of the tip of the opposite external ear he reaches the ventricle at a depth of 5 cm., and by making a bilateral opening, he is able to irrigate the ventricle through and through. Neisser reaches the anterior horn at a depth of 2 to 5 cm. through the frontal lobe, at point F2 on Fig. 614, p. 648. Likewise, from points P and Occ, one can reach the lateral ventricle at a depth of 3 cm. from the surface of the brain.

In pathological collections of fluid the walls of the ventricle are more or less dilated; they may be stretched sufficiently to render the walls extraordinarily thin, so that finally the cerebrum may represent a bladder filled with fluid, the thin wall being composed of the stretched-out brain substance. Under such unusual conditions, fluid may be found on puncture at any portion of the calvarium and not very far in from the surface. In cases of moderate internal hydrocephalus, also, we may find it very convenient to insert the needle above the middle of the transverse portion of the lateral sinus about two cm. above the external occipital protuberance, directing it forward exactly in the horizontal plane, or somewhat obliquely upward and forward; in this way one punctures into the posterior horn of the lateral ventricle.

In order to puncture the inferior horn, according to the measurements which have been established by Lannelongue and Mauclaire on children from two to four years of age, the needle should be introduced just above the external auditory meatus, in a line which runs horizontally backward from the marginal process of the malar bone, and ends slightly above the external occipital protuberance. The inferior horn can also be reached at a depth of about three cm. in the brain tissue from points T2 and T3 on Neisser's figure on p. 648.

PUNCTURE OF THE FOURTH VENTRICLE

This we have performed several times, but only after the dura of both cerebellar hemispheres, together with the occipital sinus, has been exposed. Exactly in the angle of the inverted Y which is formed at this place by the dura of the medulla oblongata and of the cerebellum (see point 1 on Fig. 616), the needle was slowly and carefully introduced in the median line, proceeding forward and at an angle of about forty-five degrees upward from the horizontal, until fluid flowed from the needle. In this manner the roof of the fourth ventricle was penetrated, but the important centers

on its floor were not injured. We have seen no disadvantage arising from this puncture, but, on the contrary, there has resulted a favorable influence upon the manifestations of intracranial pressure.

PERMANENT SUBCUTANEOUS DRAINAGE OF THE VENTRICLE

If in permanent drainage of the ventricle the tube is conducted out through the skin, a high degree of danger is incurred. As

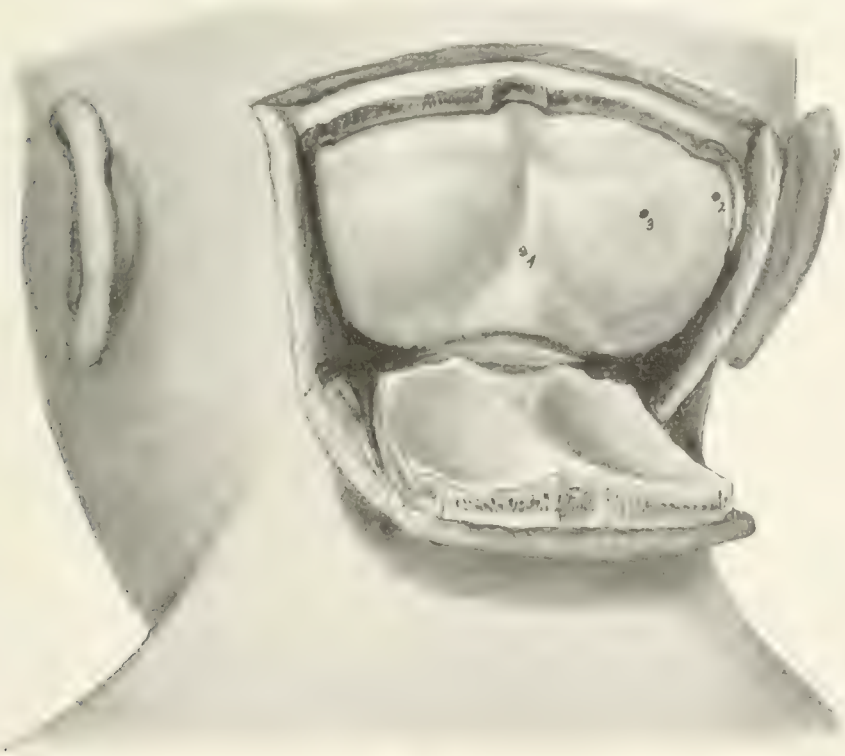


FIG. 616
Points for puncture of the fourth ventricle.

time passes, on account of the continuous saturation of the dressings decomposition and infection cannot be prevented. However, if the most minute care is exercised, this form of drainage may be employed for several weeks. Broca has shown from the literature that children with open sutures in the skull have died as the result of ventricular drainage; he, however, personally was able to cure one case, a four-year-old boy, in whom ossification of the sutures

had occurred, by long continued drainage. G. A. Sutherland and Watson Cheyne use for intracranial drainage in hydrocephalus bundles of catgut, which they place from the lateral ventricle to the subdural space. Nicholas Senn employed for the purpose a fine rubber drain which conducted the fluid from the ventricle out under the skin, and at the same time made elastic pressure upon the skull.

Mikulicz attempted to increase the insufficient outflow of fluid from the ventricles by creating a permanent connection between the brain cavities and the loose connective tissue situated under the galea aponeurotica. The fluid from the ventricle was to be in this way conducted to a place from which, in accordance with experience, absorption should be rapid. To carry out this plan, he used a fine gold tube, 2 cm. long, of a diameter of 3 mm., which could be attached to a thin oval plate 1½ to 2 cm. in diameter. This technique does not seem to have been generally imitated, and we were not aware of it when we employed for carrying off the

FIG. 617
Drill used for brain puncture.

excessive fluid a thin-walled gold-plated silver tube of a diameter of 2 mm. The technique is shown in the following case:

The patient was a boy of six years, affected with hydrocephalus. The largest circumference of the head was 69 cm. The nasion-inion line was 37½ cm. Fontanelles and sutures showed a moderate degree of dehiscence. It was decided to drain the ventricle on the right side in the temporal region, that is to say, through a mute area; the central sulcus was marked out on the shaved scalp, and the point chosen was 4 cm. horizontally behind the foot of the sulcus.

A small flap with a base of about 2 cm., composed solely of skin and galea aponeurotica, was dissected up; the periosteum was divided and peeled back on either side (Fig. 618, Plate 102). Then, with the drill pictured in Fig. 617, with a diameter of 2 cm., the same as that used for puncture of the brain, the skull was perforated, without injuring the dura. A good-sized aspirating needle with a silver cannula fitting snugly over it, was then introduced through the dura into the brain in the direction of the lateral ventricle until fluid came away (Fig. 619, Plate 102); the depth

Permanent drainage of hydrocephalus by implantation of a cannula.

Fig. 618. General view: drill hole after clearing off periosteum.

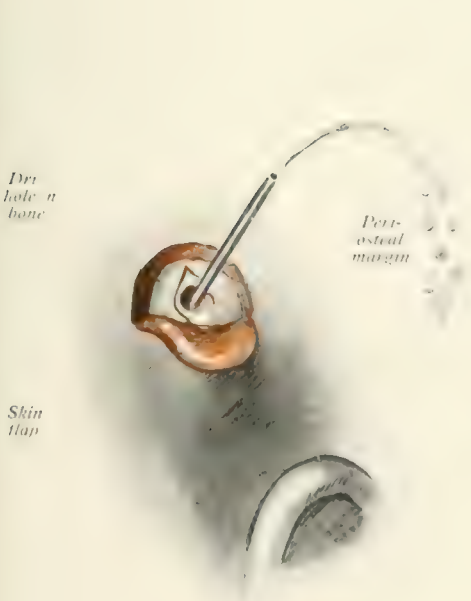


Fig. 619. The cannula is introduced into the lateral ventricle.

Fig. 620. A steel staff has been passed into the silver cannula, and on this the cannula is cut off.

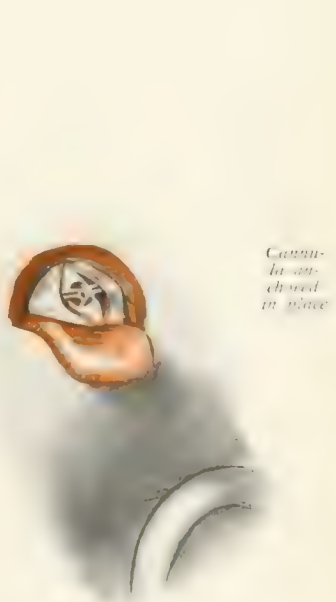


Fig. 621. The cannula is made fast under the periosteum.

was 5½ cm. Then, passing the tube one-half cm. still farther in, and holding it solidly, the aspirating needle was withdrawn. In its place a steel staff of the same size was introduced into the cannula the silver cannula was cut off with strong scissors, 1 cm. above (a knitting needle may be used for this purpose), and upon this the surface of the bone (Fig. 620, Plate 102), so that after the steel staff was removed, the silver cannula could be broken off at this point.

The silver tube was cut longitudinally by two short nicks with fine-pointed scissors down to the bone, and the two tongues of silver which were thus obtained were bent over outward until they came to lie upon the surface of the bone (Fig. 621, Plate 102). They served the purpose of holding the little tube solidly in relation to the bone so that it could not slide into the cranium. In order to prevent its being extruded, the periosteum which had been freed up on either side was replaced over the tongues of silver and sutured with catgut, in such a manner as not to obstruct the lumen of the tube. Before the tube was fastened in place in this way, it was adjusted by withdrawing it slightly or introducing it further to the point where the fluid flowed the most freely. By passing a fine probe through the tube, it was freed of blood clot, and then the little flap of skin covering the mouth of the tube was carefully sutured in place. The cannula opened into the subcutaneous tissue and nowhere came in contact with the suture line.

During the first three days the cerebro-spinal fluid leaked through the wounds and the stitch holes. Then, when the wound had healed solidly, it accumulated in the subcutaneous tissue and induced an edema which reached down to the lids on the right side, and soon also involved the other eye. But after a few days the edematous swelling diminished. This occurrence was repeated twice, which showed the fluid was finding an exit. In the fourth week there formed a fluctuating tumor the size of a plum over the operative site, the contents of which were absorbed under light compression, but reappeared soon after.

In this condition the child was discharged, six weeks after operation; the circumference of the head had diminished from 59 to 56 cm., and the general condition was good. Favorable reports came from the parents at intervals. Repeated requests to see the child again with permission to remove the cannula, which has been in place since January 19, 1909, have brought a decisive negative answer,

saying that the child was much better and had developed satisfactorily from the mental point of view.

The gold-plated silver tube can, therefore, be permitted to heal in place without causing disturbances, if it is anchored in such a way that no motion is allowed. But as soon as fluid ceases to run, it should be removed; for this purpose a simple skin incision is necessary. Accordingly there is no necessity for using absorbable metal such as magnesium. If after a few months the cannula no longer functionates, a new tube may be introduced into the brain cavity in another place.

A number of patients have died weeks or months following the operation. In several of these autopsy has shown that the hydropic ventricle was entirely empty, which finding demonstrates the practicability of the technique.

The cannula allows not only direct exit from the ventricle, but fluid also oozes out in capillary spaces between the cannula and the opening in the brain, even if the inner opening of the cannula has been closed by granulations, or, as the ventricle becomes smaller, by the brain mass itself.

PERMANENT DRAINAGE OF THE POSTERIOR HORN

from the upper portion of the occipital fossa we have carried out in the following manner:

After the skin flap was freed up, the periosteum stripped to either side and the hole drilled in the skull, at a point 7½ cm. back of the upper origin of the external ear, and 5½ cm. from the sagittal line, in order to avoid the occipital pole, the cannula was introduced at a level 3 to 4 cm. above the line which joins the external occipital protuberance and the upper origin of the shell of the ear. The cannula was directed horizontally forward and obliquely downward and inward, and, in this hydrocephalic patient, a five-year-old boy, at a depth of 55 mm. measured from the outer surface of the bone, ventricular fluid spurted out in a stream.

In cases in which the sutures have become ossified, that is to say when the skull is absolutely rigid and unyielding, one should not be satisfied with permanent drainage alone. One can more rapidly relieve the increased intracranial pressure by making an osteoplastic flap. For this purpose, however, the dura need not be opened,

as after the fluid has been emptied from the ventricles by the drainage, the dura then conforms to the reduction of space.

PUNCTURE OF THE CORPUS CALLOSUM, AFTER THE METHOD OF ANTON AND VON BRAMANN

The purpose of this technique consists in creating without any considerable damage to the brain substance as permanent as possible a connection between the large ventricles and the subdural spaces, in order in this manner to induce a balance in the pressure relations. With this purpose the corpus callosum is bluntly divided in its most anterior section on the roof of the anterior horn. An incision is made 3 cm. long down to bone a little behind the bregma and slightly to the right of the middle line, the periosteum is scraped away and the skull penetrated with the largest size Doyen burr. Through a small opening in the dura, a cannula with an olive tip is introduced carefully between this and the surface of the brain, without injury to the sinus, as far as the falx, and then it is carried downward along the falx until it perforates the corpus callosum, and the fluid comes out in a stream. By shoving the cannula backward and forward, the opening in the corpus callosum may be transformed into a slit 1½ cm. long; the cannula is then removed.

If the large fontanelle, as so often occurs in hydrocephalus, is still open, this opening into the skull is employed. The skin-and-periosteum incision is made on its right lateral margin, and the dura is opened at a place which is free from veins.

This technique is often employed in hydrocephalus, neoplasms accompanied by hydrocephalus and choked disc, as well as in many forms of epilepsy, in non-purulent meningitis and tower skull with choked disc. The favorable results are expressed by a diminution in the severity of all the symptoms of increased intracranial pressure. It may in some cases be of great importance if the internal hydrocephalus which accompanies tumors, and which often confuses the local symptoms, might be removed, or at least relieved by such a preliminary or accessory operation, which would render the possibilities of diagnosis much easier.

The method, however, is not without danger, nor is it so effective as we expected it might be. Moreover, results can occur only if the subarachnoidal spaces possess the ability to absorb the fluid in the quantity which is drained off. This is not always the case, as

is shown by a child of two and one-half years with acquired internal hydrocephalus on whom this operation was performed, and in whom, two months later, autopsy showed that in place of the original internal hydrocephalus, an external hydrocephalus of high degree had developed. In this case, even in the subcutaneous tissue into which the fluid had oozed in considerable quantity, no absorption had taken place, so that an operation for permanent subcutaneous drainage would have also been useless.

The following case will serve as an example of the technique:

A fifteen-months-old boy was taken with inflammation of the cerebral meninges in April, 1908. Hydrocephalus gradually developed. The von Pirquet reaction was negative. On entrance to the hospital, on December 1, 1908, the fundi were normal; nevertheless, the child gave the impression of being blind. Spasms of a rather considerable degree were present in the extremities, and all the reflexes were increased. The head was held ordinarily upon the left side, and correspondingly the left occipital bone was flattened out somewhat. The largest circumference of the head was 59 cm. Measured behind over the parietal tuberosities, the skull showed a width of 16 cm., the large fontanelle was 8 cm. wide and 5 cm. long. Operation was performed under superficial chloroform anesthesia, December 2, 1908.

At the posterior border of the anterior fontanelle, 2 cm. to the right of the middle line, a sagittal incision 3 cm. long was so made that its posterior half lay upon the parietal bone (Fig. 622, Plate 103). The incision went down to bone and the periosteum was scraped aside. Then toward the front the aponeurotic layer covering the anterior fontanelle was divided until the posterior portion of the fontanelle was exposed, and beginning at the forward margin of the parietal bone, the dura was incised as far as the anterior end of the incision. The Bramann probe cannula was introduced through the opening in the dura medially as far as the falx cerebri (in this case 2 cm.) (Fig. 623, Plate 103). Then the cannula was introduced carefully obliquely downward and forward along the falx to a depth of 8 cm., as measured from the dura, until clear cerebro-spinal fluid came away in considerable quantity (Fig. 624, Plate 103).

In other cases the cannula has only had to be introduced 5 or 6 cm., because in hydrocephalus the corpus callosum is often displaced upward. If the fontanelle has already become closed or

Puncture of the corpus callosum, after Anton and v. Bramann.

Fig. 622. Exposure and incision of the dura.

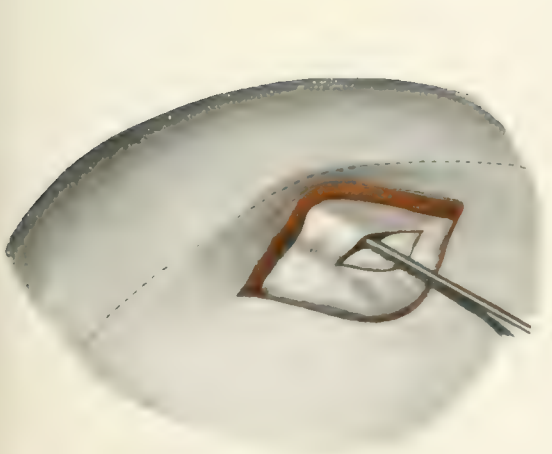


Fig. 623. The cannula is introduced subdurally as far as the falx

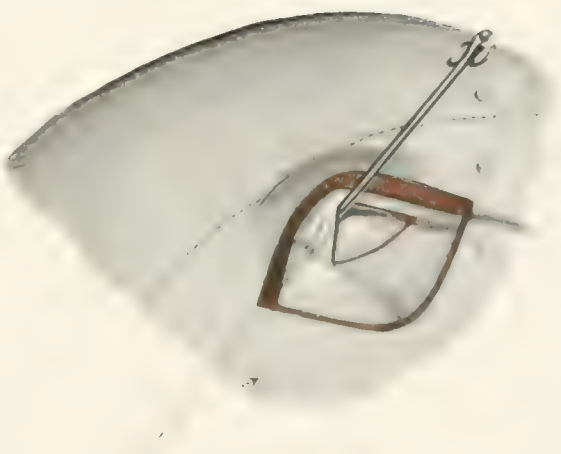


Fig. 624. The cannula is pushed through the corpus callosum.
The opening through the corpus callosum is enlarged by moving the end of the cannula back and forth as indicated by the arrows, but not in so large an arc as depicted.)

is too small, a hole is drilled through the parietal bone, 1½ or 2 cm. to the right of the middle line and 1½ cm. behind the coronary suture, using a Doyen burr with a diameter of 15 mm.

The cannula was then moved backward and forward in the depths (Fig. 624), so that the corpus callosum was bluntly divided in the sagittal plane for about one cm. Finally, the slit in the dura

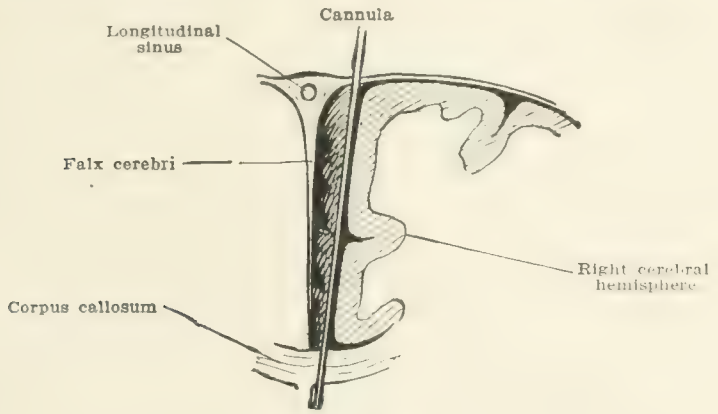


FIG. 625

Position of the cannula after penetrating the corpus callosum.

was closed with one interrupted suture, and the skin and periosteum sewed up.

In a few cases we have seen the brain protrude from the small opening with such great tension that suture of the dura was found to be impossible.

After the operation the child was bright, but he died suddenly thirty-six hours later. Autopsy showed an opening 12 mm. long on the right anterior section of the corpus callosum, but no hemorrhage and no meningitis; moreover, all four ventricles were markedly dilated from the hydrocephalus.

CHAPTER 21—OPERATIVE TREATMENT OF BRAIN ABSCESS, PURULENT MENINGITIS, CRANIAL TUBERCULOSIS AND BRAIN INJURIES: CLOSURE OF DEFECTS IN THE SKULL, PLASTIC RESTORATION OF THE DURA, ENCEPHALOCELE AND PERICRANIAL SINUS

TRAUMATIC BRAIN ABSCESS

In the recognition of brain abscess the etiology plays a very important rôle; in any case, the diagnosis is very uncertain unless the primary source of infection can be demonstrated. Doubt still exists as to whether idiopathic brain abscesses may occur; at least in proportion to other types of brain abscesses, they must be very uncommon.

Every injury to the brain which is complicated by wound infection may also give rise to a brain abscess; this is true for all sections of the brain. Those cases which follow immediately upon an injury —for instance, after penetration by a foreign body or a compound fracture of the skull—we designate as *acute traumatic abscess of the brain.*

Since the membranes are also involved in such cases in the injury and as well as in the infection, we have first to do with a meningitis. If, now, the suppuration extends into the loose areolar connective tissue of the arachnoid and pia, there results a diffuse purulent leptomeningitis, which is practically without exception fatal. In other cases the inflammation is limited to the immediate neighborhood of the brain injury, in which event there results a more or less definitely circumscribed focus of infection in the cortical substance of the brain and its immediate vicinity—that is to say, a brain abscess.

Acute traumatic cortical abscesses are usually located in the immediate vicinity of the wound, in the region of the contused brain substance. In a certain measure they represent a retention of pus in a wound pocket or beneath a displaced bone fragment. Corre-

spondingly, such wounds have, as a rule, a septic appearance, and pus is likely to issue from between the wound edges. The condition is associated with symptoms of meningeal irritation, and local manifestations of irritation or paralysis depending on the portion of the brain involved. In this connection we may consult Fig. 519, on page 529. The abscesses which arise early are hardly to be differentiated from traumatic suppurative meningitis. An abscess practically always requires several days, or even a week or two, for it to develop to such an extent that its presence becomes noticeable. The reason why on one occasion a rapidly fatal purulent leptomeningitis occurs, and in another case a brain abscess develops, are as yet unknown.

Chronic traumatic brain abscesses may arise from the same causes as the acute abscess, and may even at times develop from an acute abscess, if the infected region of the brain is rapidly walled off from the surrounding normal tissue, and, with a mildly virulent infective organism or as the result of greater resistance of the living tissue, all the manifestations assume a less stormy course.

Finally, in every chronic suppurative condition of the bones of the skull of traumatic origin, it may occur that as the result of advancing venous thrombosis the infective organism may be carried into the substance of the brain. In cases of extreme chronicity—abscesses are known to have existed for many years—acute exacerbations will frequently occur, which practically always lead to or accompany an increase in the size of the abscess. Although chronic abscesses are, as a rule, surrounded by a layer of tissue which forms a sort of capsule, the abscess membrane, they may, as the result of acute exacerbations, during which the membrane becomes softened, break into the ventricle or into the arachnoidal spaces. The result in either case is fatal, if a suddenly arising edema of the brain does not cause death beforehand. Prompt diagnosis and operative evacuation alone can prevent this.

In diagnosis of chronic traumatic brain abscess, differentiation must be made between the symptoms which arise from the injury, and those which result from the development and extension of the abscess. After those primary symptoms which depend upon the contusion and concussion of the brain and hemorrhage have disappeared, there usually follows a period comprising it may be months or years, during which the patient's well-being is completely uninterrupted or is troubled only by short periods of disturbance, the

so-called latent period. This is usually followed by the general symptoms of increased intracranial pressure and the late symptoms referable directly to the brain abscess. It depends entirely upon the functional importance of the affected region of the brain whether focal symptoms are observed early, late, or not at all. It is particularly surprising that large territories, even of both cerebral hemispheres, may melt away under a suppurative process without a single symptom pointing to the severe disturbance. In injuries and suppuration of the frontal brain, and more recently, also, in abscess of the temporal lobe, psychic disturbances have been observed; in the latter case they affect particularly the sexual sphere.

The gradual development of the abscess with its accompanying inflammatory manifestations may cause corresponding symptoms which repeatedly appear, while the patient is otherwise in an apparently good state of health, and then disappear immediately. Headaches, emanating from the scar, and psychic depression, as well as vertigo, nausea, occasional high tension of the pulse and decreased pulse rate, and finally febrile fluctuations of temperature, merit the most grave consideration. But brain abscesses may run an entirely feverless course; this is especially the case with an encapsulated focus, if absorption does not take place.

But in addition to trauma, brain abscesses arise as sequelæ to inflammation or suppuration of the cranial bones, or as the result of disease of the nose, ears, and air sinuses (rhinogenous and otitic brain abscesses). For the sake of completeness, we should mention also actinomycosis, cerebro-spinal meningitis, and tuberculosis as etiological factors. As we have already seen, conglomerate solitary tubercles, on account of their clinical manifestations, have been classified with the brain tumors. But collections of tubercles may break down in the brain just as in other portions of the body, suppurate, and give rise to all the pathological manifestations of an abscess. In clinical manifestations, as a rule, there is no difference whether the case is one of a solid or a broken-down conglomerate tubercle. From these cases we must distinguish the foci of suppuration which develop in connection with chronic tuberculosis of the cranial bones; these should rather be classified with the form just described, which follows carious bony processes.

The same cause which gives rise to brain abscess may lead to extra-dural collection of pus.

Opening an abscess in the temporal lobe.

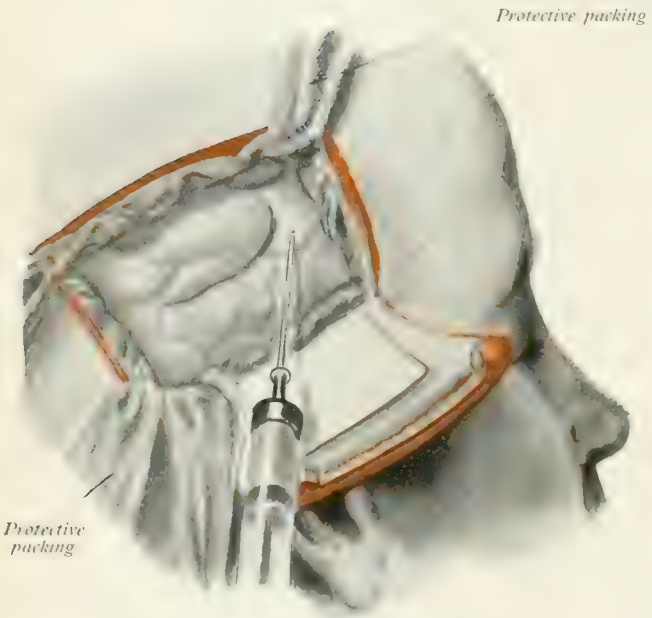


Fig. 627. Exposure of the temporal lobe.

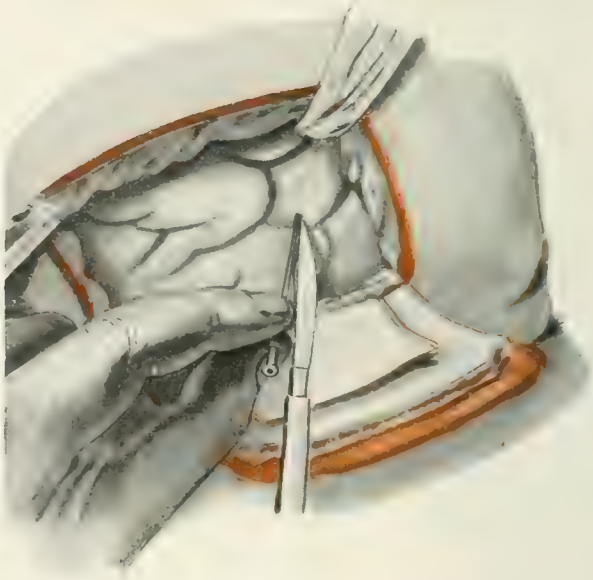


Fig. 628. Incision is made along the exploring needle.

Fig. 629. The finger is introduced into the abscess cavity.

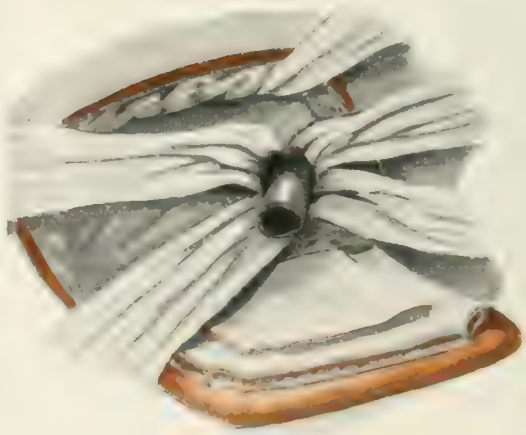


Fig. 630. Drainage of the cavity.

INDICATIONS FOR OPENING THE SKULL

If the diagnosis of a brain abscess has been decided upon, or even if there is a well-grounded suspicion of the presence of a brain abscess, the skull should be opened. The dictum *ubi pus, ibi evacua,* holds good here even more than elsewhere, on account of the threatening danger to life, which cannot be met in any other manner. The experienced observer will have already noted the edematous changes in the granulations of the wound which perhaps still persist.

The opening in the cranium must be made sufficiently large, or must be enlarged to a satisfactory size. At times the dura mater shows a yellowish or dirty discoloration over the abscess. Usually pulsation of the dura mater is absent, but it should be well understood that its presence does not absolutely rule out brain abscess. Diagnostic puncture should first be made after the dura has been turned down in the form of a flap, because if the dura is intact the pus may enter the arachnoidal space from the puncture hole and infect the meninges.

Protection of the meshes of the arachnoid from all contact with infected pus may be most safely accomplished by means of *packing of the subdural space.* This is carried out by inserting tightly between the cut edges of the dura and the surface of the brain around the entire operative field strips of sterilized iodoform or vioform gauze (see Fig. 627, Plate 104). In such cases the dural flap is not cut too close to the bony margin, but at a distance of about one cm. Now if, after turning down the dural flap, one makes an oblique incision from each corner of the dural opening to the corresponding corner of the bony opening, there results three narrow little flaps above, to the right, and to the left. By seizing these with toothed clamps and lifting them up, one can readily find his way into the subdural spaces. But the large lower flap must be turned up also and lifted away from the brain, and the subdural space at the base must be carefully packed off, for the danger of infection at this point is particularly great.

Only after this protective tamponade is carefully carried out do we proceed to the puncture and the opening of the abscess. This can be immediately performed if the case is one of a very superficially situated abscess, which is immediately recognized after open-

ing the dura. The layer which is to be incised in such case no longer consists of functionating brain tissue.

But if we have to open an abscess which lies deep in the medullary layer, the first task is to localize exactly the focus of infection. In the first place, the brain is punctured with a diagnostic needle, using one which has a lumen of about 2 mm. diameter. If the pus is under pressure, if it is not of too tenacious a consistency, it comes out immediately through the needle without the necessity of using suction. But if no pus appears, suction is made with the syringe, meanwhile gradually withdrawing the needle. If the result is negative, the punctures must be repeated at various depths, and in several directions. The pus may be so thick and tenacious that it cannot even be aspirated. Then, if there is a well-grounded suspicion of an abscess being present, a knife should be introduced into the brain mass without hesitation to allow the pus to make its exit through a wider opening. This is the only way to save a threatened life.

When the abscess is found the needle is allowed to lie undisturbed in position. Then a scalpel is introduced alongside it, dividing the layer of brain which covers the abscess cavity, which, corresponding to the size and depth of the abscess, may be a stretch of several centimeters. Instead of a knife, one may use a small hemostat, which is introduced alongside the needle, and by opening it the brain mass is pushed aside. Naturally one observes all the general rules governing an incision into the brain substance. Small retractors are introduced to hold the edges of the wound apart, the pus is carefully wiped away as soon as it appears, and the entire cavity examined minutely. For not infrequently one finds a point of pus issuing from a small space in the depths, and a probe leads to a second cavity. Then the most practicable thing to do is to replace the probe with the little finger and to divide bluntly the partition wall, using the utmost care, but at the same time being so thorough that we finally have to do with a single cavity, so as to create the most favorable conditions for recovery. Moreover, one should always remember in opening a brain abscess that there may be several which are entirely separate from each other.

When the pus cavity has been cleaned out, the infiltrated walls in acute septic cases should not be curetted, because in this way new infections may be induced. If a true abscess membrane has been formed, which occurs not only in tuberculosis but in chronic

abscesses, the membrane must be removed. Then in the deepest portion of the cavity, one or two good-sized drains, depending on the size of the cavity, are introduced, and these are packed around with vioform or iodoform gauze. The widely split cavity is held open in its entire extent so that it may heal from the bottom, and no retention of pus be allowed. For this packing we employ iodoform gauze on account of its antiseptic influence.

Naturally the osteoplastic flap is only laid back loosely over the packing, and it is sewed down with at most only a few sutures.

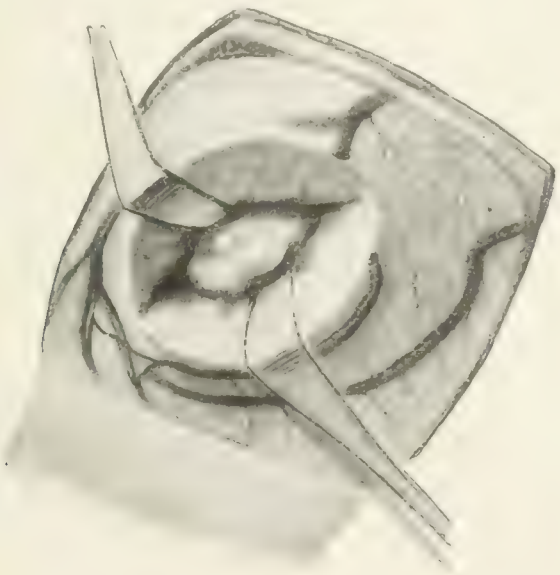


FIG. 626
Deep-lying brain abscess.

The dressing is saturated very rapidly with cerebro-spinal fluid, and the upper layer down to the packing should be changed daily; the latter is allowed to remain three to five days.

Fig. 626 represents the conditions which were found in an eighteen-year-old boy. The protective packing is not shown. It was a case of metastatic abscess in the left facial and arm center, which occurred as the sequel of a traumatic empyema of the chest.

TECHNIQUE IN OTITIC BRAIN ABSCESSES

Special significance attaches to brain abscesses which arise from the middle ear. They occur more frequently as a sequel of chronic purulent ear disease and in particular of cholesteatoma, then as a

consequence of acute inflammatory suppurations. A further cause is found in those diseases which lead to necrosis of the bone enclosing the organs of hearing, and particularly, therefore, in osteomyelitis. According to the location in the petrous portion of the sequestrum, or of the point at which the purulent inflammation has taken its exit from the middle ear, the localization of the abscess which arises in the brain depends. Generally speaking, we can lay down the rule that the temporal lobe is infected through the upper portion of the tympanic cavity or through the roof of the mastoid antrum, while infection of the cerebellum proceeds from the mastoid cells. But suppuration may extend from the labyrinth into the posterior fossa.

At times the clinical picture is so obscure that it is difficult to differentiate between meningitis and brain abscess. In the first case lumbar puncture will usually, but not always, give a cloudy purulent fluid, while in brain abscess the fluid is clear. For abscess we look for a normal temperature, particularly absence of febrile manifestations, and a slowed, rather high tension pulse; for meningitis, rigidity of the neck.

It may also remain a matter of doubt whether the focus of infection is located extra-durally or within the brain, and finally whether the brain abscess is located in the temporal lobe or in the cerebellum. Further complications may also arise from a suppurative process in the middle ear, after it has involved the mastoid antrum and the cells of the mastoid process, giving rise to a septic thrombosis of the lateral sinus. Headache and fever are the only symptoms of this serious affection until, accompanied by repeated chills, the typical picture of pyemia appears, and the presence of the disease, usually too late, however, can no longer remain in doubt.

If on account of the difficulties which are frequently met with the diagnosis cannot be determined, but the signs point to a severe infectious process within the cranial cavity, it is advisable in every case to undertake operation. With careful technique it can do no harm, but loss of time increases the extreme danger for the life of the patient.

For the opening of all otitic brain abscesses the incision of von Bergmann, which encircles the upper margin of the auricle at a considerable distance, offers the best known method of approach, after, of course, the necessary chiseling open of the mastoid or the radical operation has been performed. This method also gives plenty

of room for the exposure, in suppurative processes, of the posterior surface of the petrous portion practically as far as the middle line. Should the abscess not be limited to this region, but involve at the same time the region of the tip of the pyramid, or from this point should spread still farther forward, it is necessary only to lengthen von Bergmann's incision in that direction, which is the more readily possible because most surgeons do not make a practice of preserving the bone in such severe purulent conditions. In this way we reach the region which we employ for the approach to the Gasserian ganglion. This temporal method exposes, in fact, the entire middle fossa, back practically as far as the upper margin of the petrous portion. In such cases we attempt to preserve the bone, and therefore frequently employ a different incision, forming a rectangular flap above the auricle with the base directed upward. This method allows us in case of necessity to extend our opening farther in any direction without having to sacrifice the flap of bone which has been cut.

It is of importance to know that temporal abscesses are sometimes multiple. At operation one must always bear this in mind, and carefully examine the abscess cavity by retracting its walls.

Otitic abscess of the cerebellum are likely to involve the anterior lateral section of the affected hemisphere. Since the tympanic cavity is bounded below by the roof of the bulb of the jugular vein, we can understand readily how the suppuration extends into the vein and thrombophlebitis occurs.

The difficulty of diagnosis is rendered more apparent if an extra-dural abscess, serous meningitis, and abscess of the cerebellum and of the temporal lobe occur in the same patient, which we have known to happen.

Infection from the middle ear may also give rise to *extra-dural abscess*, without involving the brain itself. The symptoms are likely to be similar to those in brain abscess, so that, generally speaking, the differentiation is impossible. For that reason, if the skull is opened, the dura should always first be loosened up from the petrous portion of the temporal bone in the middle or posterior fossa for a short distance, in order to expose extra-durally the neighboring tegmen tympani and the upper semi-circular canal, or the internal auditory meatus. Likewise we are accustomed to lift up the lateral sinus out of the mastoid sulcus in which it lies, in order to examine the posterior surface of the petrous portion, since

we know that the sigmoid fossa very readily becomes involved. In the procedure described, it is important in the examination of the upper and posterior surface of the petrous portion that a strip of bone should be preserved on the surface of the skull corresponding to the upper margin of the petrous portion: this acts as a sort of support, and prevents later the caving in of the two osteoplastic openings.

SEROUS MENINGITIS OF OTITIC ORIGIN

Not only may cerebral, cerebellar and extra-dural abscesses arise following otitis media, but there may also occur as the sequel of a purulent process in the middle ear and the neighboring portions of the bone, collections of masses of inflammatory serous exudate, which are under high pressure, and limit the space within the closed cranial cavity much like a neoplasm or an abscess. Operation will discover pus in the middle ear, in the antrum, and in the mastoid cells, and perhaps also an extra-dural abscess about the sinus. The temporal lobe or the cerebellar hemisphere, when exposed by an osteoplastic opening, show a high degree of tension of the dura and no, or practically imperceptible, pulsation. Puncture of the brain shows no pus anywhere, but only clear fluid which issues under strong pressure subsequently from the puncture hole. Since after operative removal of all affected tissue the severe brain manifestations may disappear and a cure result, as we have several times observed, we are accordingly furnished with proof that nothing more has been present, and particularly no brain abscess. At other times puncture has given no satisfaction, and the dura has had to be opened, which for reasons already given should best be done in the form of a flap.

Upon the analogy of the foregoing clinical picture with serous spinal meningitis, we will recur in the section on operations on the spinal cord; for here there is also an acute as well as a chronic form, which is induced by suppurative necrotic bony process in the arches and bodies of the vertebræ.

OTITIC ABSCESS OF THE TEMPORAL LOBE, WITH SEROUS MENINGITIS OF THE POSTERIOR FOSSA

The patient, a nineteen-year-old girl, on the 25th of September, 1909, was taken with severe pain in the right ear. Three days later a swelling appeared in the region of the mastoid process,

which her physician incised. No pus was evacuated at that time, and no symptoms of suppuration of the middle ear were present. On admission to the Augusta Hospital (Oct. 2, 1909) she complained of violent pains in the right occipital region and of vertigo. The right ear-drum was bulging and pulsated. The soft tissues of the neck from the right of the mastoid to about the middle of the sterno-mastoid muscle were swollen and of doughy consistency. A clean-looking incised wound, about 3 cm. long, was found at the point of origin of that muscle. There were no signs of thrombosis of the sinus or of the jugular vein. The right mastoid was extremely sensitive to touch and percussion.

The diagnosis of acute otitis media and mastoiditis was made. Paracentesis of the drum was performed on October 2, and a few drops of pus evacuated. The right mastoid was then chiselled open, and its cells as well as the antrum were found filled with pus. The mastoid sinus was visible for a short distance in the upper portion of the wound; it was not thrombosed. The dura showed a grayish-green discoloration. After the bone cells were thoroughly cleaned out, the wound was packed. The symptoms abated, and the temperature fell.

The wound healed gradually, and the pains in the ear disappeared. Slight rises of temperature persisted, occasionally reaching 100.4 in the evening. From time to time the patient showed slight stupefaction, and complained of dizziness, and occasionally vomited. No symptoms of meningitis were present; examination of the fundi showed no changes whatever. The movements of the eyes were free, without nystagmus. When the patient was looking downward, she had a sensation as if everything were whirling around her from left to right. The symptoms, especially the vertigo, then regressed in the following weeks, so that early in November she was able to leave the bed, and on December 23, 1909, left the hospital.

On January 27, 1910, the patient was readmitted one evening in a critical condition. She complained of excruciating pain over the entire head. On the slightest movement of the head she became dizzy and vomited. The region over the right ear was highly sensitive to pressure and percussion. The fundi showed no abnormality, and the pupils reacted promptly. There existed, however, a coarse nystagmus on looking to the left, and this became especially marked when the patient was looking to the right. There

was also weakness of the left arm and leg and a considerable exaggeration of the knee-jerk on the same side.

These findings, coupled with the history, led us to suspect a *temporal abscess.* January 28, 1910, the skull was opened in the left temporal region. After marking out the central sulcus on the shaved skull, and placing the hemostatic suture, we made an osteoplastic flap just above the ear, with its base below, in such manner that the central sulcus lay in the anterior portion of the opening. The dura was tense and did not pulsate. A flap of dura was turned down. The pia-arachnoid showed a milky cloudiness, and was edematous.

After protective tamponade (Fig. 627, Plate 104), puncture between the base of the central region and the temporal lobe yielded at a depth of 3½ cm. a sanguino-purulent fluid. The cortex was incised at this point (Fig. 628, Plate 104), the opening dilated with forceps, and the index finger was introduced into an abscess cavity about the size of a walnut (Fig. 629, Plate 104). A medium-sized rubber drain was introduced, and through this still more purulent fluid drained away. Since the abscess was comparatively small, and being mindful of our former experience with multiple foci, we made several diagnostic punctures in various directions into the temporal lobe, but without result. The introduction of gauze strips about the drain completed the operation (Fig. 630, Plate 104).

The packing of the subdural space was allowed to stay in place. Since the wound margin could not be sutured, we made an exception in this case and allowed the hemostatic suture to remain. The wound was packed with gauze and the dura and the osteoplastic flap were laid back over this packing. On the following day the hemostatic suture was removed with moderate hemorrhage, and the dressing was changed daily thereafter on account of saturation with cerebro-spinal fluid. Following the operation the brain protruded through the wound so that on the seventh day the prolapse was half the size of a fist, and the bone flap stood out perpendicularly, and there was no longer drainage through the tube.

The vertigo had already diminished to such an extent that the patient while lying down could look freely to right and left, and could also rotate the head; these motions no longer caused vomiting or nausea. On changing the dressing on the tenth day the prolapse of the brain was found to be larger still. The drain had fallen out from the brain and was removed together with all the

packing. From this time on the dressing was changed only at intervals of four or five days. Vertigo and nausea became still less, and the nystagmus had disappeared.

Temperature and pulse during the whole course of the convalescence showed very little change from that preceding the operation; the temperature varied between 98.6 and 100.2 and the pulse between 100 and 100.8. Since the general physical condition remained satisfactory and temperature and pulse had dropped to normal, on the twentieth day after operation the attempt was made by operation to lessen the prolapse to such a degree that the flap could be turned up over it and light pressure could be made with bandages.

We have several times in such cases successfully accomplished a reduction of the prolapse by means of compression. A preliminary condition of this form of treatment is that all inflammatory manifestations have disappeared; temperature, pulse, and general condition must give evidence of this. Superficial necrosis and sloughing may be present, without offering any contraindication. The objection may be offered that any increase in intracranial pressure, such as is induced by this method, even if very gradual, is accompanied by dangerous possibilities. This is true of all pathological processes within the closed cranium, even if, like early tumors, they involve only a limited area. But experience has taught us that in cases of brain prolapse compression may be exerted even to a considerable amount under proper conditions without danger and usually without symptoms.

However, it is hardly ever possible to reduce the prolapse to the level of the surrounding skin. But if we succeed in lessening its size, it is practicable to free up the skin, to sew it over the opening, and in that way to get rid of it.

In our case the prolapse was brought back during an interval of thirteen weeks to a point where it projected only 2½ cm. from the surrounding skin, and about the margins, its surface for the most part was covered with epidermis. The outermost layers of the bony plate were necrotic at the edges. On May 2, the entire epithelialized surface, together with the thin layer of scar tissue over skin surface as well as brain, was everywhere carefully removed. Then we were able to proceed carefully with the finger between the prolapsed tissue and the bony plate, which could be accomplished very easily without injury to the brain. The bony plate, freed up in this manner, was mobilized so that at the two basal angles two

diverging incisions could be made. Thereupon the entire prolapse lay exposed in the bony opening, covered in its lower half by the shrunken dura. All bleeding vessels were carefully tied off with catgut threaded on a needle.

After the prolapse had been cleaned of remnants of epithelium and the bony plate freed of the narrow necrotic strip at its margin, which could be done without difficulty on account of the granulations at the line of demarcation, two diagonal incisions were laid in the upper angles of the wound, and starting from these the scalp was undermined and mobilized. In the same way the skin which covered the bony flap was freed up for a considerable distance in the direction of its base. Then under moderate tension, the osteoplastic flap could be sewed into its original place to the margin of freedup skin, leaving no opening behind. The prominence at its highest point was about 2 cm. The margin of the bony plate lay free under the skin and did not touch the edge of the bony opening.

Following this operation the patient complained during the first few days of headaches and a feeling of tension, but these disappeared within a week. The patient reacted but slightly in pulse and temperature. The dressing had to be changed for the first time only after six days, as no cerebro-spinal fluid was coming away; the wound had adhered by first intention without necrosis at the margin, and the protrusion of the bony plate was still less. Sixteen days later the sutures were removed, and on May 19 the patient was discharged. Later the hernia gradually disappeared completely, and the bony plate was found to have healed in solidly at the level of its surroundings; it no longer projected even on straining and on coughing.

In the course of the next few weeks, during which the patient returned frequently for examination, symptoms developed which pointed more and more to a disease process in the region of the right cerebellar hemisphere. More particularly were there present severe pains in the right occipital region, nystagmus on looking to the left and right, as well as cerebellar ataxia. Accordingly on September 9, 1910, she was readmitted to the hospital.

On September 14 the right cerebral hemisphere and a narrow median portion of the left were exposed in the customary manner. Upon opening the tense dura on the right side there spurted out a stream of clear fluid. After the dural flap was completed, the

pia-arachnoid was found to be markedly edematous, particularly in the region of the vermis. Its edema was relieved by punctures and incision into the meshes of the arachnoid. After withdrawing the aspirating needle, a cyst about the size of a hazel nut reformed immediately over the vermis, so that here arachnoidal tissue had also to be cut away. Clear fluid came away also in considerable quantity from below, from the spinal canal. An exact examination of the neighborhood of the right cerebellum, during which the facial and auditory nerves were rendered distinctly visible, showed nothing pathological, and the same was true of palpation and repeated puncture of the cerebellum. The findings corresponded entirely to a serous meningitis. After turning back the dura, the osteoplastic flap was sewed in without drainage.

Headaches, nystagmus, vertigo and ataxia had completely disappeared within a few days after this operation. The general condition of the patient improved markedly, so that she could be discharged well on October 22, 1910. The cure has been permanent, and the patient has been restored to her ability to work.

OPERATIVE TREATMENT OF PURULENT MENINGITIS

In the last few years there had been reported in the literature several cases of circumscribed purulent meningitis in which the diseased membranes have been exposed. These cases were practically without exception cases of otitic meningitis or purulent inflammation of the cerebral membranes complicating compound fractures of the skull. As regards the otitic process, Lucae and Jansen have seen one case of purulent leptomeningitis of the temporal lobe get well after dividing the dura and draining. Bertelsmann had a successful case of otogenous meningitis in which lumbar puncture yielded a turbid fluid, in whom he made an osteoplastic opening. MacEwen, in his masterly work on purulent affections of the brain and spinal cord, makes mention of the fact that of twelve cases with circumscribed purulent lepto-meningitis six were operated on and recovered; of these five were in the middle section of the skull and one in the posterior. And Kümmell even earlier successfully treated three cases of otogenous suppuration by widely opening the temporal bone and dividing the discolored dura.

Generally speaking, it is agreed that in circumscribed meningitis of otogenous origin, the pus should be given exit by an extensive osteoplastic flap, wide opening of the dura, and drainage. Natur-

ally this must be preceded by opening the middle ear, and in case of necessity the labyrinth. The greatest difficulty arises in making an early diagnosis, which may be aided in case of necessity by repeated lumbar puncture, and in the earliest possible operation. If we find in the lumbar fluid a large content of pus cells, which render the fluid turbid, and signs point to suppuration of the labyrinth, even though other symptoms of purulent meningitis have not yet clearly developed, immediate exposure of the dura along the petrous portion, beginning at the lateral sinus and ending at the internal auditory meatus, is urgently indicated. If the purulent turbidity of the cerebro-spinal fluid has been caused by uncomplicated abscess of the cerebellum, the error is discovered as soon as the dura is opened; the procedure is, nevertheless, not without value; on the other hand, as a rule, this very operative procedure is indicated. Wittmaack has reported two cases of beginning purulent meningitis following suppuration of the labyrinth and cholesteatoma, operated on with good results.

In case of circumscribed meningitis arising from compound fracture of the skull the same method should be employed, supplemented, if need be, by removal of the discolored and crushed portions of the brain. Witzel cured one patient in whom, following injury by a splinter from an exploding shell, an advancing suppurative meningitis had developed.

In *diffuse suppurative meningitis,* the conditions are somewhat different. The question as to whether or not they should be treated surgically is not yet determined. As yet cases are very infrequently reported in the literature.

Kümmell, following the analogy with celiotomy in peritonitis, advocates to a more extensive degree than formerly the treatment of purulent affections of the cerebral membranes by widely opening the cranial cavity. He reports a severe meningitic process arising as a sequel to a fracture of the base of the skull in which lumbar puncture showed pus. The patient was cured by trephining the skull on both sides. Two openings were made a little larger than a half dollar, one on each side, in the anterior occipital region, extending onto the parietal bone. The tense dura was divided across the whole width of the trephine hole. The arachnoid was markedly injected and thickened. Gauze strips were introduced into both openings extending as far as possible into the posterior fossa.

Poirer got a successful result in fracture of the skull with diffuse

meningitis by means of bilateral trephining. Witzel observed meningitis to develop following a fracture of the base of the skull, with bleeding from the right ear. After exposure of the right temporal lobe, division of the dura and packing, the meningitic manifestations gradually disappeared and the patient got well. MacEwen operated five times on diffuse cerebro-spinal lepto-meningitis, with one recovery. Further references to the literature are unnecessary here.

GUMMATOUS MENINGITIS

It is a well-known fact that products of syphilitic infection do not always yield to specific treatment. Gumma of the skin, bone and tongue which have resisted all other therapeutic measures for years have been found to yield after curettage and excision. It seems entirely rational to employ a similar technique in such cases of syphilitic pachymeningitis as give rise to severe cerebral disturbances, and cannot be improved by any other treatment. Operative procedures should particularly be invoked before the cortex and deeper lying sections have been permanently destroyed by the disease process. Conservative treatment is the more indicated, the more important the physiological functions which reside within the affected sections of the cortex. Experience with other portions of the body teaches also that after carrying out the above described surgical procedures mercury and potassium iodide prove their curative influence, while salvarsan not infrequently shows itself ineffectual in cases involving the central nervous system.

Horsley, in cases of meningeal inflammation of syphilitic origin which do not yield to other treatment, makes a trephine opening, lays bare the affected area over a sufficient extent by dividing the dura, and irrigates for a considerable time with warm corrosive sublimate of a strength of one to twenty thousand or even one to ten thousand.

For the sake of completeness, it should be said that *actinomycosis* may pass over to involve the brain and may give rise to foci of suppuration within it.

OPERATIVE TREATMENT OF TUBERCULOSIS OF THE CRANIAL BONES AND OF THE BRAIN

Tuberculosis of the flat cranial bones is usually a perforating condition, whether it be that a cheesy sequestrum involves its entire thickness or—a much less frequent occurrence—that tuberculous

granulations have penetrated the bone as far as the dura. The outer surface of the dura is not infrequently covered with tuberculous granulations; naturally at operation these must also be removed. As a rule curetting suffices.

In a ten-year-old boy of poor origin who, following measles, had suffered for years with a scrofulous eczema, a small painful swelling appeared about the middle of May, 1907, on the right side of the skull, following a fall on the head. This rapidly increased in size, and at the beginning of June it was aspirated in a clinic. The discharge of the purulent contents relieved the patient for a short time. Our examination showed on the right half of the skull a semi-fluctuant spherical tumor about 7 cm. long, which showed evident pulsation.

On June 7 the tumor, the size of a plum, was exposed through a skin incision. After freeing up the skin the periosteum was cut in a circle about the tumor and freed up all around (Fig. 631, Plate 105). At the margins of the tumor, four drill holes were made in the skull and connected by means of the Dahlgren forceps, and then the free portion of bone, together with the tumor, was removed (Fig. 633, Plate 105). On the dura there was left behind a small mass of cheesy granulations, which was curetted away (Fig. 632, Plate 105). The wound was packed with iodoform gauze and the skin sutured. There were no changes of pulse or temperature. On June 13 the iodoform gauze was removed, and there was fitted into the defect of the skull a piece of bone taken from the breast of a goose, cut to proper size, which had been sterilized by repeated boiling, and the skin was carefully united over it.

At first the goose bone healed in, and on July 27, when the patient was discharged, the wound was entirely closed. He then spent a convalescent period of four weeks in the country. During this period a small fistulous opening, secreting pus, developed in the scar. At the beginning of 1907, the patient was again admitted and the goose bone, which was entirely surrounded by granulations, was removed. The wound cavity was closed and the patient had no further symptoms. It was not until Easter, 1911, that slight attacks of vertigo appeared, which first began in connection with the old wound. During his two weeks stay in the hospital no further source could be found, and later there were no more of the same sort of attacks.

Suppurating tuberculosis of the cranium.

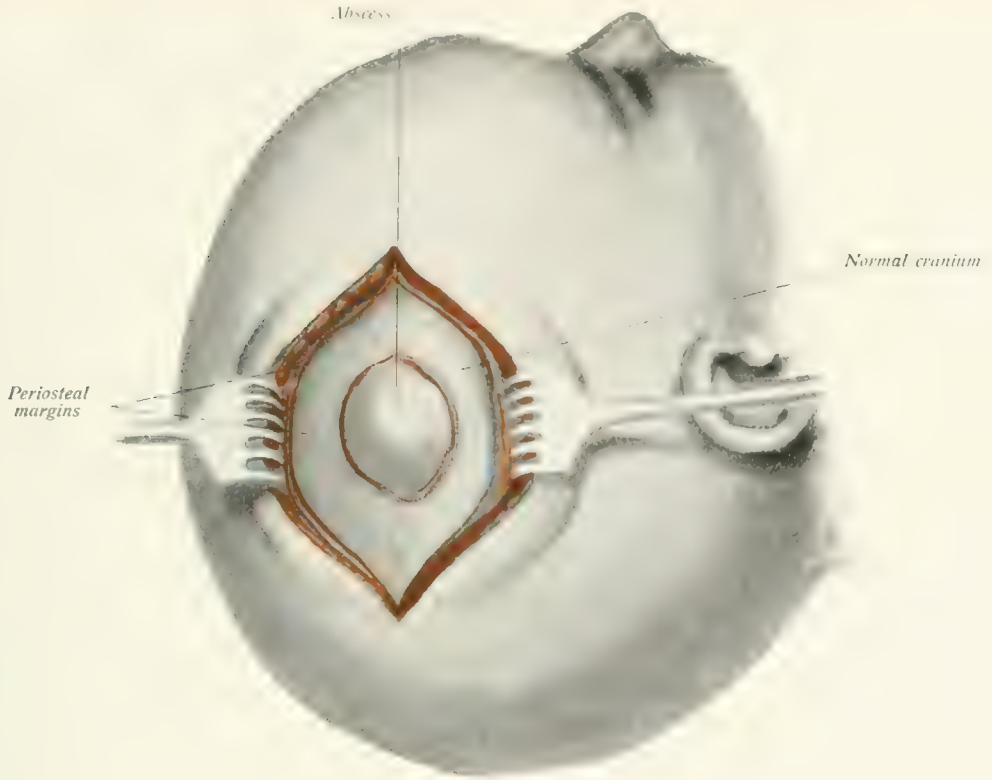


Fig. 631. Exposure of the abscess and the surrounding normal bone.

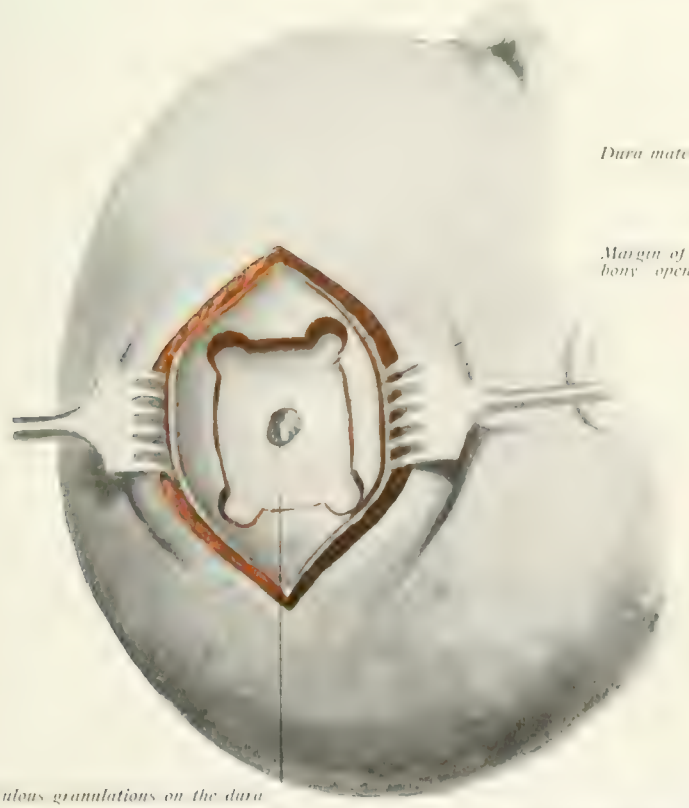


Fig. 632. The tuberculous portion of bone is removed.

Fig. 633. Section of bone after removal.

At our last examination, July 8, 1913, the well-developed young man of sixteen showed in the middle of the right central region at the operative site, a hollow the size of a quarter dollar and 1 cm. deep, the floor of which was formed by a stiff hairless scar, which on severe straining projected a very little above the surrounding margin of bone. There had been no symptoms of any sort for two years, and the young man had worked hard as a pupil in an electro-technical establishment.

At times the cheesy granulations extend for a considerable distance from the surface of the dura, so that an extensive osteoplastic opening becomes necessary, and even this does not always completely expose the focus of disease. But, in spite of the fact that the infection may involve an extensive area, it limits itself, as a rule, to the dura and spares the brain substance.

However, at times an abscess may form in the brain substance, and as has been observed in one case (see Krause, "Surgery of the Brain," Rebman, New York, Vol. I, p. 112), there may be tuberculous infection of the brain substance itself. The operation for this type of brain abscess departs from the technique described on page 665 only in so far that the tuberculous abscess membrane should be completely removed if possible.

In such operations, after complete removal of the conglomerate tubercles, we consider it important to pack the wound cavity for several days with iodoform gauze. Even if necrosis of the mass has not begun, in spite of careful observance of the rule that all incisions should be made in normal tissue, it is possible for infected bacteria to be left behind, which give rise to recurrence. This technique corresponds exactly to that which we are accustomed to employ for surgical tuberculosis elsewhere. After five days at the earliest the entire wound, if it shows no infection, may be closed by suture; otherwise the packing is allowed to remain until the wound is clean.

OPERATIVE TREATMENT OF INJURIES OF THE BRAIN: TREATMENT OF INTRACRANIAL HEMORRHAGE

As to the treatment of compound fractures of the skull, the essentials have been stated on pages 82-85.

Intracranial hemorrhage not infrequently demands surgical interference. First, when the extravasation has attained a sufficient

size, there appear the manifestations of increased intracranial pressure. As this always requires a certain length of time, there occurs a free interval between the moment of the injury and the appearance of intracranial pressure symptoms which, depending naturally upon the nature of the vessel injury, may vary in length from an hour to several days, or even to more than a week. During the interval, neither brain symptoms nor manifestations of concussion, and particularly of laceration, are present. For all the symptoms of the various injuries of the brain readily merge one into the other, and often unite to form a very complicated clinical picture.

Symptoms of increased pressure resulting from extravasation of blood are not to be differentiated from those resulting from tumor formation except that they are of more rapid onset. With hemorrhage headache, vomiting, disturbances of consciousness, and changes in the pulse and respiration occur; choked disc does not often develop in this condition.

As regards involvement of the consciousness, first there occurs, with increasing cerebral pressure, irritation of the cortex, and as a result conditions of excitement or delirium. Later on these manifestations of irritation quiet down, and in their place appear apathy, somnolence, and finally complete loss of consciousness. The characteristic pressure pulse is of strong tension, full volume, slow, and at first regular. As regards its frequency, the individual variations and the influence of any rise in temperature which may have been present beforehand must always be taken into consideration.

As the pressure increases still further, inducing manifestations of paralysis, the pulse becomes rapid, of small volume, fluttering and irregular. Until the paralytic stage has completely developed the pulse may vary and at one time may be slow and at another time rapid. The respiration, corresponding to the pulse, is at first slowed, increased in depth, and stertorous; later it becomes more rapid, and finally assumes the Cheyne-Stokes type. Also in judging the frequency of the respiration, one must take into account the individual conditions and other factors which influence its frequency. At first the irritative symptoms, headache and slowing of the pulse, predominate; later individual manifestations of paralysis appear, until finally these dominate the clinical picture, and, accompanied by unconsciousness and the changes in pulse and respiration just described, usher in death.

The local symptoms, which arise from the region of the brain which is directly compressed, are at first irritative. Extradural hematoma in the central region may also give rise to Jacksonian attacks. The irritation gives way more or less quickly to the manifestations of paralysis. The symptoms vary, depending upon the section of the brain which is involved and the predominance of irritation or paralysis. There should be mentioned clonic and tonic muscular contractions, which may also assume the character of Jacksonian attacks, paralyses which occur as monoplegias or hemoplegias, exaggeration or loss of reflexes, aphasic disturbances of all sorts, and hemianopic manifestations.

Serious hemorrhage may occur either within or without the dura; the first occurs much more frequently from the large arachnoidal veins than from the brain arteries. Intradural hemorrhages are characterized by a slower development and accordingly a longer free interval, and moreover by the fact that they do not remain circumscribed, and that they give rise to a considerable irritation of the cortex and finally of a predominance of the symptoms of increased intracranial pressure. Extradural hemorrhages arise at times from the torn vessels of the diploë, but usually are the result of injury of the anterior or posterior branches of the middle meningeal artery, that is to say, vessels which allow for the rapid exit of a considerable quantity of blood under considerable pressure; for that reason the symptoms appear more rapidly. As the uninjured dura possesses considerable resistance, there is formed a circumscribed hematoma which, lying between cranium and dura, exerts a considerable pressure upon a definite region of the brain, and thus gives rise to well-developed focal symptoms, according to their location usually of a motor sort. The dura is very adherent to the base of the skull, and as a result of the injury will tear in this locality more readily than on the convexity of the skull; accordingly at this point, that is to say at the base of the skull, the hemorrhage is, as a rule, intradural.

Besides injuries, *hemorrhagic pachymeningitis*, which we see particularly in alcoholics, leads also to extradural hemorrhages of considerable size, which form repeatedly, accompanied by severe headache and apoplectic manifestations. Naturally an extradural hemorrhage may occur at the same time with an intradural hemorrhage, as we have frequently seen. The dura then appears, after removal of the hematoma which lies upon it, much darker than

ordinary, with a bluish-red color, and on account of the increase in the amount of the cerebro-spinal fluid, it is frequently fluctuant. Incision evacuates a usually thin sanguineous fluid which may contain a few clots. After the removal of such extradural and intradural collections of blood, the symptoms of pressure as well as the local symptoms usually disappear rapidly, provided no serious laceration of the brain is present.

In the treatment of intradural as well as extradural hemorrhages, the skull must be opened as soon as the symptoms demand. Nothing need be said about the technique except a few words on the treatment of the branches of the meningeal artery.

For ligation of the trunk of the middle meningeal artery, we recommend, and have repeatedly employed with success, the method described under the technique of removal of the Gasserian ganglion (see Vol. I, p. 246). Since we cannot determine with assurance from the clinical manifestations whether the anterior or the posterior branch of the middle meningeal or whether the trunk itself is torn, the formula of Krönlein is not to be depended upon.

In order to tie off the middle meningeal artery, it is not necessary to open the cranial cavity. After temporary resection of the zygoma the internal maxillary artery may readily be found, and the meningeal artery can be located at the point where it is given off. But exposure of the middle fossa leads one immediately down upon the extradural hematoma which, in fact, gives the indication for operation and under any circumstances must be removed.

Cushing has employed his submuscular temporal method (see p. 643) to drain the subdural space, if fractures of the base have been accompanied by hemorrhage. According to his opinion, there is no better way to reach an extradural hemorrhage from the meningeal artery, or, as may be added, to open an abscess of the temporal lobe.

In apoplexy caused by cerebral hemorrhage, in order to relieve the acute danger to life, it has been proposed to tie off the carotid artery (Horsley, Chipault), to remove the collection of blood after trephining (Franke), and finally to puncture and aspirate, according to Neisser. Experience so far has not been particularly encouraging, but surgical interference may sometimes well be invoked (Broca, Marion) in the sequelæ such as paralysis, cortical epilepsy, and cyst formation in the hematoma.

Personally, even in small external openings, we do not limit ourselves as might be the case in a compound fracture of the thigh, to an antiseptic or aseptic dressing, but on the other hand we enlarge the skin wound so that pockets or hollows may not be left at any point, remove all foreign bodies such as hair and sand, as well as blood clot, cut away the crushed soft parts, remove splinters of bone and wipe away or otherwise remove any destroyed portion of the brain tissue. In case of necessity, the wound of the dura must be enlarged also, so that there may be no retention at any point, and in that way necrosis be encouraged.

When the hemorrhage has been carefully controlled, the entire wound cavity cleaned by sponging out with sterile gauze, and rendered visible by opening it wide, then it is packed to the bottom with sterilized iodoform or vioform gauze. We have seen very dirty wounds of the brain recover favorably under this method of treatment. It is most advantageous to use the gauze in the form of tapes, because the wound is to be closed over them, so far as this may be done by sutures, and the tapes may be removed through small openings after five or six days, or in case of necessity later. By partially suturing the wound, we in a certain measure prevent the occurrence of the much-dreaded prolapse of the brain, which happens the more readily if the pia also is torn over a considerable extent. Frequently enough it becomes necessary to later cover over a large prolapse by a flap graft or a graft containing the external table of the skull, in order to induce healing.

To be sure, even severe injuries with bruising of the brain substance through an external wound may run a perfectly aseptic course. Bony splinters which have been completely detached also heal in the brain substance conditional to the fact that no septic infection has occurred, but years later a fistula may form. In spite of this the disturbance which results even in the central region is at times slight, and Jacksonian convulsions do not always necessarily follow.

If threatening symptoms arise referable to the brain, if bony splinters which have been driven into the depths cause manifestations of irritation and paralysis, we have ground for operative interference, as is shown by the following case.

REMOVAL OF SPLINTERS OF BONE FROM THE CENTRAL REGION

On October 30, 1908, a young man of twenty-one, while working in a field was struck on the middle of the right side of his head by the prong of a machine used for turning over hay, causing a wound about 1 cm. long. He did not lose consciousness but vomited severely. He fell to the ground and could not get up again. On admission, November 9, he complained of severe headache, which was localized in the depths of the wound, the edges of which had adhered, without having been sutured. This lay 5 cm. to one side of the middle line and 3 cm. in front of the central sulcus as located by the formula of Krönlein. There was at this point a visible depression in the bone (Fig. 634, Plate 106). Temperature was 100.2, pulse 70; there was spastic paralysis of the left arm and leg, with patellar and foot clonus.

The X-ray showed at the middle of the right parietal bone a defect about 1½ cm. across, and below this four shadows of unequal size which it was inferred represented bony splinters.

On November 10, an osteoplastic operation was undertaken to expose the right central region. After reflecting the osteoplastic flap, there came into view the tightly drawn non-pulsating dura, which was torn in some places (Fig. 635, Plate 106). The hole which was found in the middle of the bony plate was funnel-shaped, with its larger opening internal, and was filled with necrotic grayish-red masses of brain tissue, the removal of which from within exposed the under side of the healed scalp wound covering the small external opening of the bone. Corresponding to the hole there was found upon the injured dura a protruding mass of brain substance, which measured about 3 cm. square, from which three rather superficially situated bony splinters about the size of a bean were removed. But since the X-ray had shown a fourth one lying in the depths of the brain substance, the brain mass was carefully probed through the opening in the dura, and at a depth of 1 cm. met with resistance. Thereupon followed the careful extraction of the last splinter with anatomical forceps (Fig. 636, Plate 106).

The wound was loosely packed with iodoform gauze which was shoved all about between the dura and the brain for a short distance, as the brain at this point did not seem absolutely clean. The healed scalp wound was reopened and the drainage was brought

Removal of a bony splinter from the central region.

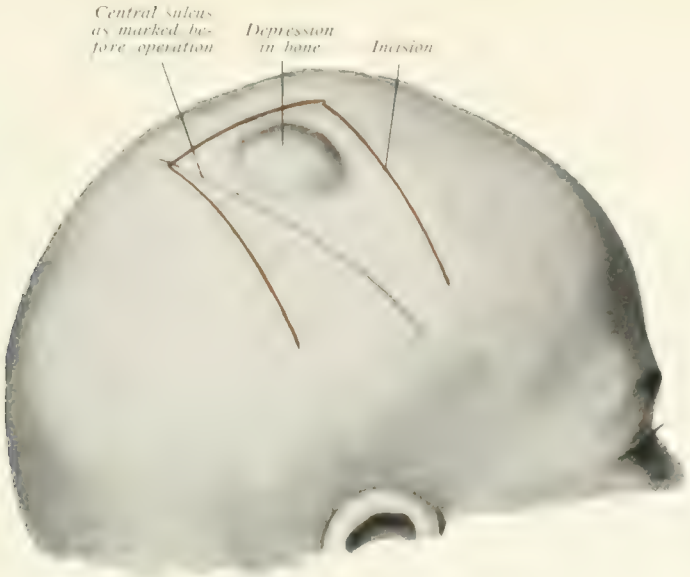


Fig. 634. Incision for osteoplastic opening.

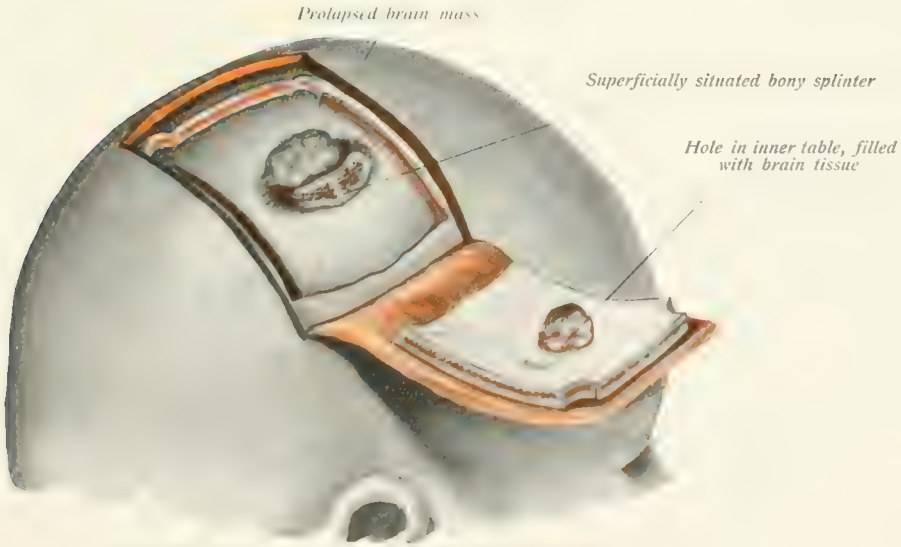


Fig. 635. Exposure of the injured central region.

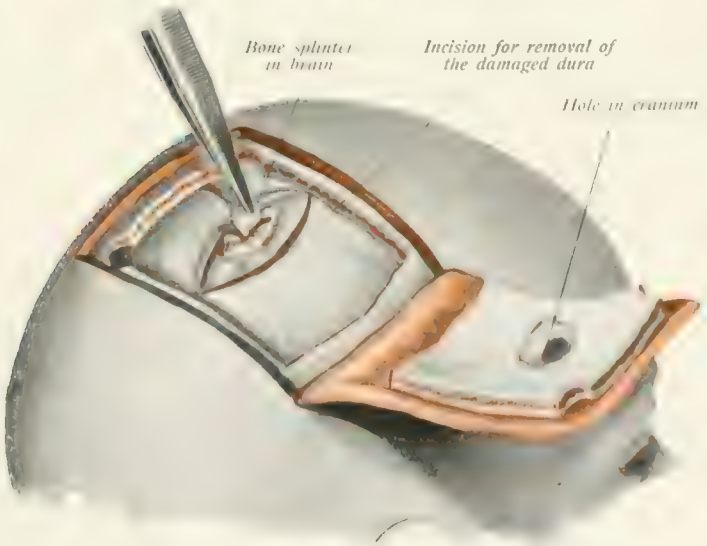


Fig. 636. Extraction of the fourth splinter, situated within the brain.

out through this wound. In addition an iodoform gauze drain was brought out at the anterior upper corner of the flap. Then the operative wound was closed in the regular manner by replacing the osteoplastic flap and carefully suturing the skin. The drains were removed nine days later. Healing occurred without any fluid coming away. Temperature and pulse showed no marked variations.

Immediately following the operation voluntary motion in the thumb and index finger disappeared entirely, but by the twelfth of November the patient could move the fingers of the left hand for twenty times or so without much fatigue. In the following days the mobility and strength of the arm improved considerably, but the leg showed no changes in this respect; although the contractions entirely disappeared.

After November 27, the seventeenth day following operation, the patient could readily abduct and adduct the left leg at the hip, and could flex and extend it. This improvement advanced rapidly in the course of the next few days and soon included the knee-joints, so that on December 4, that is to say, three and one-half weeks after operation, the patient could stand up and walk with support. Gradually voluntary control of the left ankle was restored, while motion at the toe-joints had not returned even at the time of discharge, January 10, 1909. The after-treatment consisted chiefly in practising walking, in massage and electricity.

Examination in March, 1909, showed normal findings with the exception of a persistent loss of active motion in the toes, and a limited motility in the knee-joints. This condition has for the most part remained unchanged.

BULLET AND STAB WOUNDS

In bullet and stab wounds of the brain, we limit ourselves ordinarily to the care of the external wound (see p. 85). Experience has taught us that bullet wounds of the brain in themselves involve no particular danger of septic infection, as the bullets are sterile in so far as they do not tear off septic particles and carry them along into the depths. Accordingly, if the external wound is not ragged or soiled, all that is necessary is the proper treatment of the wound and simple protective dressing. Bullets may heal in place without causing any disturbance, provided they have not met or injured any important center.

One manifestation worthy of note is the wandering of bullets within the brain. The cause of this lies in the weight of the projectile and the softness of the cerebral substance about it (see p. 86). If, as the result of severe manifestations, occasion arises for the removal of the bullet, this should take place immediately after its position has been determined by the X-ray, so that it may not have an opportunity for changing its position again.

Like bullets, portions of knife-blades of even considerable size may heal permanently in the brain tissue, if they do not give rise to abscess formation as a result of septic infection. If they cause no irritation, they are left undisturbed, and it is only when disturbances arise that we are forced to remove these foreign bodies.

REMOVAL OF A KNIFE-BLADE FROM THE TEMPORAL REGION

A thirty-two-year-old machinist was sent into the Augusta Hospital by an Accident Insurance Association for observation regarding epileptic convulsions. On entrance, he stated that five years before, while repairing a driving belt, he was struck on the right side of the head by a falling piece of metal, and from the time of that accident he had had convulsions at intervals. Those who had previously examined him stated that he was malingering, and it was not until we had X-ray plates taken that the condition was cleared up. While he was in the hospital we observed on several occasions left-sided epileptiform convulsions in the face, the muscles of the abdominal wall, and in the arm. Since the patient showed several smooth scars upon the middle of the right side of the head (Fig. 638, Plate 107), which led us to believe that he had an old injury of the skull, two X-rays of the skull were taken on February 4, 1909, lateral and antero-posterior. These showed the sharply outlined shadow of a broken-off blade of a pocket knife (Fig. 637, Plate 107), the base of which lay against the inner surface of the skull, and the point directed downward and forward into the middle fossa.

When this was explained to the patient, he was extremely surprised; he had, in fact, no suspicion of the presence of a foreign body, otherwise he would have used this to his advantage, for he had always been considered a dissembler, and further beneficial payments had been refused by the company. (When a few days after the operation he was shown the knife-blade which had been removed, he admitted that in 1893, that is to say, ten years before

Removal of a knife blade from the right temporal lobe, after 15 years.

Fig. 637. Knife blade within the cranial cavity, as shown by the x-ray plate.

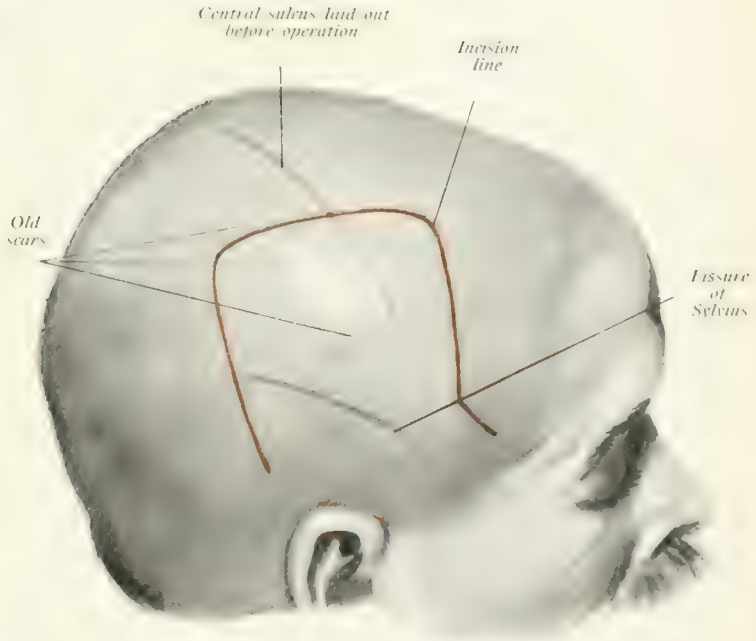


Fig. 638. Cutting out the osteoplastic flap.

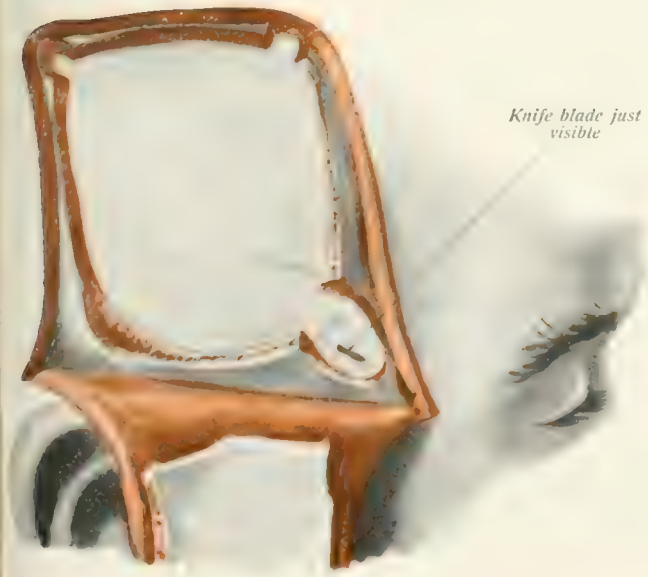


Fig. 639. The knife blade is just visible in the anterior inferior angle of the wound.

Fig. 640. Blade in process of removal, together with its attached capsule.

the injury which had been described, he had been stabbed in the right upper temporal region with a knife. Careful examination at this point showed a scar 1 cm. long. Apparently the knife-blade had penetrated the skull at this point while the other scars which lay posterior upon the right side of the head were probably due to the accident described by the patient.)

On account of the epileptic attacks and the severe headaches which came on from time to time, operation was undertaken.

Of the scars which were to be found on the right side of the head, it appeared, under consideration of the X-ray plate, that the lower one, slightly more than 1 cm. long, which lay about sagittally, and which, according to Krönlein's formula, was situated over the posterior central gyrus, represented the point of entrance of the knife.

The skull was accordingly opened over the base of the right central region, so that the scar on the scalp, which we assumed to be the point of entrance of the knife, lay in the middle of the opening (Fig. 638, Plate 107). After turning down the osteoplastic flap the dura was palpated, and we were surprised on finding its surface entirely free. It was under a certain amount of tension, but it pulsated, and no scar could be found upon it.

The skin incision was now lengthened downward at an angle of forty-five degrees from the anterior lower angle of the opening, and the bone removed at this point with rongeurs. A black metal body came into view with its broken end first (Fig. 639, Plate 107). It was surrounded by a grayish-yellow rather firm capsule. The dura was cut out in an eclipse about it so that the entire focus was exposed. One could now see the black ragged brain tissue, and the foreign body and its capsule together could be seized with smooth forceps and carefully drawn out of the brain (Fig. 640, Plate 107). For the sake of assurance, a vioform gauze strip was introduced at this place.

It should be stated that the broken-off blade still presented its broken surface in the dura, and it could be seen here more through the blackening of the surrounding tissue than through its projection. It extended directly medially downward and forward into the brain substance at about the junction of the anterior central gyrus and the frontal lobe. The blade in this case evidently had broken off on the hard internal plate, not, as is more frequently observed, on the surface of the skull.

The operative wound was closed in the typical manner by suture of periosteum and skin; the gauze strips were brought out at the anterior lower angle of the wound.

The black and eroded knife-blade measured 4 cm. long and 1½ cm. wide. The opening was made originally too high; the error was due to the X-ray pictures, in spite of the fact that several plates were taken. It might have been more suitable in this case to have made an opening similar to that used for extirpation of the Gasserian ganglion (see p. 230).

The temperature on the second evening after operation was 100.6, and the pulse 100; otherwise there was nothing of note during convalescence. The gauze strips were removed on the fifth day, and the sutures on the eighth. Cerebro-spinal fluid never appeared, and the dressing remained dry and was changed only on the two occasions noted. The wound healed without disturbance.

Immediately after the operation five left-sided epileptiform attacks occurred, which consisted of twitching of the face and moderate cramps of the abdominal muscles. After each attack, left-sided facial paresis persisted for a certain length of time. No further attacks were observed. The paresis of the left arm, which came on only after the operation, persisted for but a short time; after twelve days it had completely disappeared. At the beginning of March, 1909, the patient left the hospital in good physical and mental condition. No paralysis persisted.

The broken-off knife blade had remained fully fifteen years in the brain substance without giving rise to any disturbance. As the large and sharp foreign body extended into the central region, it gave rise from time to time to epileptiform convulsive attacks. After the removal of the blade, these reappeared on a few occasions, but then disappeared for good. Strange to say the abdominal muscles of the opposite side were distinctly involved in the convulsive attacks, an occurrence which we have only noted once before in a very vascular gliosarcoma of the left upper parietal lobe. In this case marked clonic contractions occurred only in the very beginning of the disease in the right belly muscles as well as elsewhere, and they disappeared later.

EXTIRPATION OF A PERFORATING SARCOMA OF THE DURA

Perforating dural sarcoma have, generally speaking, a tendency to extend outward, eating away the cranial bones, and then mak-

Extirpation of a sarcoma of the dura.

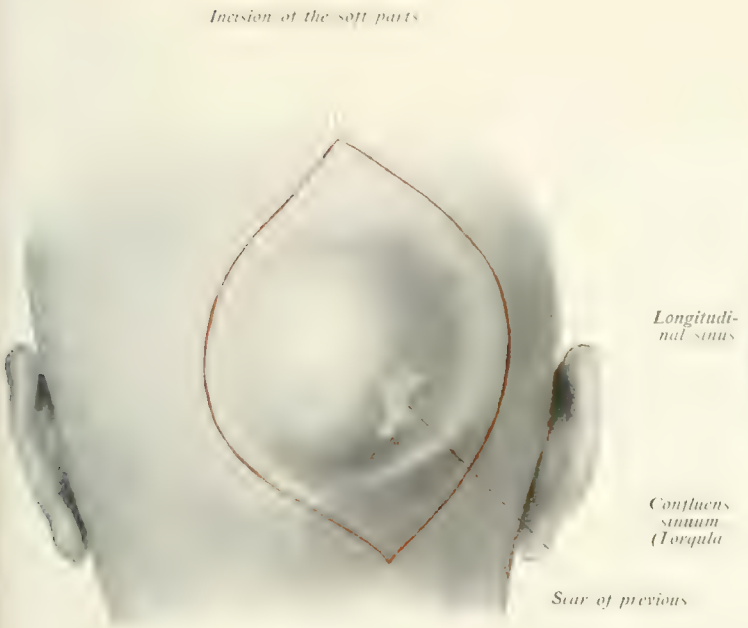


Fig. 641. Incision.

Fig. 642. Exposure of the tumor.

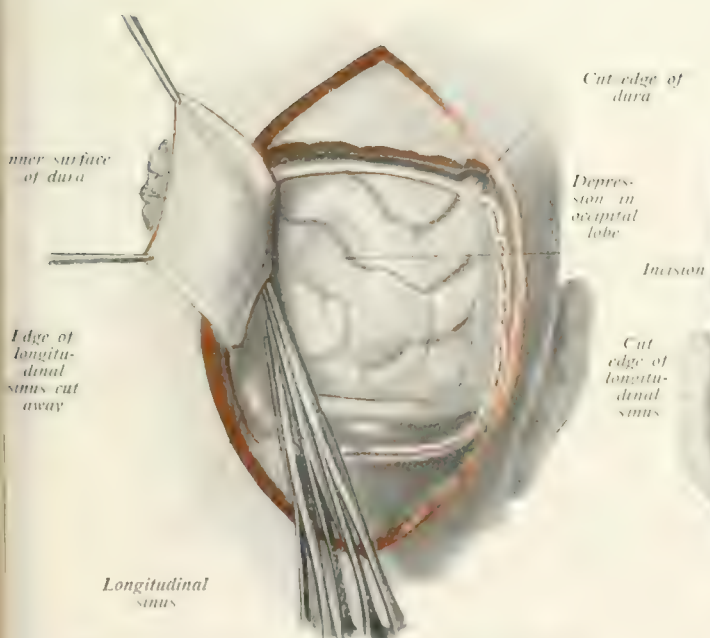


Fig. 643. In removing the tumor a strip of the wall of the longitudinal sinus is cut away.

Fig. 644. Incisions for plastic flaps to cover defect.

ing their appearance as a cystic tumor on the scalp. But less frequently growth may occur at the same time inward toward the brain. In such case the clinical manifestations may stimulate those of brain tumor.

In extirpating such growths, not only considerable sections of the cranium and dura, but also extensive portions of the large blood vessels must be removed. This can be readily accomplished according to our experience with the lateral, longitudinal and occipital sinuses. The straight sinus, on the other hand, should never be injured, because through the great veins of Galen, it represents the chief means by which the venous blood is conducted from the brain; likewise one cannot exclude the lateral sinuses on both sides without jeopardizing the life of the patient. The operation consists, roughly speaking, in a combination of an osteoplastic resection with resection of the dura. The following case will serve as an example.

A sixty-two-year old man, up to this time in good health, noticed in the preceding six months a tumor over the occipital region, which at first increased very gradually in size, but more lately had been growing rapidly. In an outpatient clinic several weeks before, a small bit had been excised for diagnosis, and the patient had then been discharged because operation was considered unnecessary. No disturbance involving the central nervous system had been observed. The patient, who except for occasional headaches complained of no symptoms, had suffered greatly in nutrition and strength during the last few weeks. He was admitted, May 18, 1911, into the Augusta Hospital with the expressed desire to be freed of the tumor under any circumstances.

On the occipital region there could be seen somewhat to the right of the middle line a spherical tumor the size of an apple (Fig. 641, Plate 108), of a rather soft spongy consistency; except for the scar representing the previous incision, it was covered with normal skin. About the base of the tumor an edge of bone could be felt encircling it, but at the apex of the tumor no bony substance could be felt. It was impossible to press the tumor back into the cranial cavity. X-ray showed in the region of the right occipital fossa an excavation and increased porosity of the bone. Symptoms of intracranial pressure as well as subjective symptoms were wanting, except for the headache; the nervous system showed no changes, both fundi were normal, and there was no hemianopsia.

On May 22, 1911, after the Heidenhain hemostatic suture was introduced, a wide oval including the skin adherent to the tumor and a considerable margin of normal skin was removed (Fig. 641, Plate 108). The tumor projected under this covering through the cranium. The bone was removed about the tumor with rongeurs, starting from a single drill hole in the right parietal bone, all the bone being removed which had been involved or eroded by the growth. This exposed the normal dura for about an inch all around the tumor (Fig. 642, Plate 108). The right lateral sinus, as well as the torcular (confluens sinuum), was situated a full centimeter away, so that they did not have to be disturbed. Accordingly, the extirpation could readily be carried out on this side. But, on the other hand, the tumor extended for a distance of 3 cm. close along the longitudinal sinus, so that on the right side this sinus had to be removed for a corresponding extent.

The dura was incised a good centimeter from the tumor on the right side, above and below, and was then lifted over in the form of a flap, carrying the tumor with it (Fig. 643, Plate 108). The inner surface of the dura showed no trace of the neoplasm, but a shallow hole was visible in the upper portion of the medial section of the occipital pole, the result of pressure.

Finally, the right lateral wall of the longitudinal sinus was removed longitudinally with scissors, and after each tiny snip with scissors the opening in the lumen was immediately closed with a mosquito snap. By applying a hemostat immediately the bleeding from the sinus could be rapidly stopped, the exit of blood from the divided section of the sinus being prevented by having an assistant pull strongly to the left the forceps which were attached to the flap. In this manner only a slight amount of blood was lost. By excising the margin of the big vein the extirpation of the tumor was concluded.

As a rule, the sinus would now have been closed by suturing it longitudinally just behind the clamps by means of very fine paraffin silk on cambric needles, but on account of collapse on the part of the patient, this had to be given up. The eight forceps were allowed to remain in place, and by means of sterile gauze they were so cushioned and fixed that they could not exert any dangerous pressure. After removal of the Heidenhain suture the slight bleeding was controlled by strong pressure on the soft parts surrounding the operative field.

Microscopic examination of the tumor showed a round-cell sarcoma which in many places gave evidence of cell degeneration and was rich in blood pigment. The wall of the longitudinal sinus, which had been removed in connection with the tumor, was overgrown with tumor elements, but these had nowhere penetrated the intima.

After the operation slight secondary hemorrhage at first appeared which demanded a change of the outer layers of the dressing, as they were saturated with blood. The forceps which lay on the longitudinal sinus were removed at the time of the first complete dressing four days after the operation; the hemorrhage had been completely controlled. At this dressing the substance of the occipital lobe, so far as it was visible in the wound, seemed to be softened, and projected in a spongy mass. An attempt was made to reduce this prolapse by packing the wound with vioform gauze and applying light compression to the dressing.

The patient recovered rapidly from the operative shock, and during the first few days he felt well and had no fever. On the third and fourth day following the operation he was very restless and at times stupefied. He suffered from a sharp headache, from frequent vomiting, and the temperature went up to 102.4, although the pulse never exceeded 84. At the same time he suffered severely from bronchitis. On the 27th of May an extensive flow of cerebral spinal fluid began, so that the outer layers of the dressing, to which for the sake of assurance iodoform gauze had been added, had to be renewed daily.

Coincident with the establishment of the flow of cerebro-spinal fluid the severe symptoms improved, accompanied by a drop in temperature, and soon completely disappeared. A stiffness of the neck, observed on May 31st, disappeared after two days. Examination at that time showed definite left-sided hemianopsia such as we have often observed after wide exposure of the occipital lobe. Otherwise examination of the central nervous system, except for a slight increase in the tendon reflexes in the left leg, showed nothing abnormal.

PLASTIC COVERING OF THE DEFECT

On June 2d, as the patient was in a satisfactory physical condition and the wound looked favorable, the brain substance projecting but slightly beyond the surface of the skin and the flow of fluid having ceased, attempt was made to cover the defect in the skull by means of a plastic. For this purpose two flaps were made four

fingers wide, the left with its base toward the neck over the left occipital region and the base of the skull, the right flap with its base over the ear in the temporal region, and so chiefly in the parietal region. Both flaps included skin and aponeurosis, but the periosteum was not disturbed, in order to avoid superficial necrosis of bone in so old a man. After they were freed up, the flaps were displaced medially in the direction of the arrows (Fig. 644, Plate 108), the left below and the right above, and were sewed carefully into place without tension at any point. The lateral defects which resulted were in large part closed by tension sutures like those shown on Plate 88, Fig. 517.

The flaps healed in place by first intention without marginal necrosis. The temperature, which on the morning of the operation was normal, rose that evening to 100.2, and on the third and fourth evenings to 100.4 and 100.6, and then fell to normal. The pulse remained between 76 and 84. During the first few days a considerable amount of fluid came away, but after that the dressing remained dry; stitches were removed on the tenth and fourteenth days. On June 12th, three weeks after the osteoplastic opening, the patient was allowed to get out of bed; two days later he went for a long walk in the garden without support.

On June 20th, the projection of the operative region which was first noticed had entirely disappeared, and in the place of the extirpated sarcoma there was a hole 2 cm. deep. Here the brain could be definitely seen to pulsate, but it was well protected by the flaps. To the right and left at the points from which the flaps had been taken there occurred a granulating strip about a finger's breadth wide. He was discharged May 20th, eighteen days after the plastic operation, feeling well and in good physical condition.

On January 11, 1913, we received news that in the year and a half following the operation the patient had gotten along very well, and that up to that time, except for occasional slight headaches, had no complaints.

Although the result in this case was good, nevertheless the bone, considering the extent to which it had to be sacrificed in extirpating the sarcoma, should have been restored by the plastic operation.

CLOSURE OF LARGE DEFECTS IN THE CRANIAL BONES

Small defects ordinarily close themselves, even in adults, by the formation of a firm scar, so that secondary operation is not neces-

sary. In children, if only the periosteum and the dura mater, which in its external leaf presents something of the character of periosteum, are preserved, bone formation takes place from the margins, while the center of the opening is usually filled permanently with connective tissue. Cranial defects of wide extent at times lead to the most severe physical and mental disturbances, and often give rise to epilepsy. If we have to do with a hernia of the brain such as may form after opening the dura mater, and in large size only after a considerable loss of this elastic protective layer, we must first try whether or not the trouble may be remedied by the employment of solid support, or whether by its use severe symptoms may be aroused; the attempt at closure by plastic operation will depend on the success of this treatment.

One of the best methods for the closure of large bony defects in the skull is that originated by König and Müller, according to which a pediculated flap is taken from the neighborhood of the defect, composed not only of skin and fascia, but containing also the outer table of the cranial bone. The technique of this procedure has already been demonstrated in two cases (p. 521, Plate 88, and p. 707, Plate 111). Whether the bony covering shall be transplanted immediately after the operation or whether this shall be done at a second stage, depends upon so many circumstances that rules for general application cannot be laid down.

Von Hacker and Garré employed flaps comprising periosteum and bone which were transplanted beneath skin and fascia. Garré forms the flap on the scalp so large that it at the same time exposes the defect in the skull so that he can carefully observe the latter. The repair flap, properly speaking, contains only periosteum and, according to König, the outer layer of the bone. It is shoved into the defect, and for this purpose it may be rotated on its pedicle as much as ninety degrees. The periosteum is sutured in place about the edges of the defect.

If during the manipulations the periosteum becomes separated from the external table, the bony plate alone is transplanted, and if this, as in one case of von Garré's, is convex on the chiseled surface, the smooth external surface is laid on the dura, or on the mass of scar tissue which takes the place of the dura, and the periosteal flap is sewed firmly over it. With this last technique we are dealing not with a flap graft, but with the implantation of a living piece of bone which has been entirely separated from the body.

But we cannot always carry out the plastic operations described, because the thinness of the cranial bones makes it impossible. In that case other serviceable methods may be employed. First we can consider the employment of pieces of bone taken from the patient himself. After injuries of the skull, we may reimplant the loose pieces of bone, as soon as the wound has been rendered aseptic, and induce them to heal in place again.

In place of the reimplantation of fragments of bone which have been broken away, we may employ flat portions which have been chiseled out of the tibia or of any other bone. But since, as experience has shown us, boiled and accordingly dead pieces of bone may heal in permanently, we may for this purpose just as well employ pieces of bone taken from the dead or from amputated limbs, which are usually readily obtainable. Before implantation, the piece of bone should be boiled for a long time and repeatedly, but not in soda solution, which softens thin bones.

Instead of using bone, other material may be employed, such as celluloid plates as recommended by Frankel, or metal plates, aluminum or silver, and finally the silver filigree of Witzel.

In a similar manner we may employ small pieces of bone which have been broken off in trephining for the purpose of covering the defect. But in order to induce favorable healing of pieces of bone which have been entirely separated from their source of nutrition, one must take particular care to insure absolute hemostasis, to suture the periosteum and the dura, and see to it that the fragments rest upon living tissue. Any piece of bone of considerable size may be employed for plastic purposes. For instance, we many years ago implanted successfully a portion of bone 8 cm. long which included the anterior cortex of the tibia, together with the periosteum, into a defect of the anterior wall of the pelvis, which arose as the result of resection of an osteosarcoma of the pubic bone. We have always considered the preservation of the periosteum of importance, a belief which has been substantiated by the recent experiences of Lexer.

PLASTIC RESTORATION OF THE DURA MATER

Not infrequently, on account of disease or degeneration, we are forced to excise a portion of the dura, or the dura may be lacking over a circumscribed area of the brain after a scar resulting from an inflammatory process is excised.

The organic restoration of a loss of substance of the dura has for its purpose the prevention of any injury to the pia-arachnoid by the bone, and particularly the prevention of adhesions arising between the surface of the brain and the inner surface of the skull. Attempts have been made at replacement of the dura by various methods, but we will consider only the two more important. Finsterer * has employed for plastics upon the dura pieces of hernial sac, that is to say peritoneum, which have been kept stretched in alcohol. Kirschner † first employed fascia lata experimentally on dogs in 1909. Since from previous experimental and clinical experiences we know that only those grafts which are taken from the patient himself persist and functionate, we accordingly employ for this purpose the fascia lata of the individual himself.

The first dural plastic was performed on man by Körte, in January, 1910; he took a piece of the fascia lata of the proper size and transplanted it on the exposed surface of the brain. Kirschner recommended this method also to prevent cerebral hernia or to overcome it, by implanting strips of the fascia over a wide surface covering the defect and fastening them by a double suture *en piqué*. The following case will serve as an example.

No nervous or mental disease had occurred in the family of the patient. On December 23, 1903, the boy of eleven years, who at that time had been entirely well, received a blow from a horse's hoof and was brought unconscious to the hospital, where he regained consciousness for the first time six hours later. On the same day some splinters of bone which were present were removed; six weeks later the Müller-König bone plastic was performed, and three weeks after this a transplantation of skin from the right upper arm was undertaken.

At the beginning and end of October, 1912, two severe convulsions occurred, during which the patient bit his tongue and twisted his head markedly to the left. At the same time clonic contractions began in the left hand, and very soon general convulsions of the head and of the extremities began, which lasted as long as ten minutes. After waking up, there remained no paralysis or paresis, only the gait was for a considerable time dragging and wavering. As the young man after his injury could no longer carry out his work as a farmer, he came to us for operation. In the anterior

* Beiträge zur klinischen Chirurgie, 1910, Vol. 66, p. 193.

† Verhandl. d. Deutschen Gesellschaft für Chirurgie, 1910, Vol. II, p. 223.

section of the right half of the head there were present extensive scars which in part were adherent to bone (Fig. 645).

The first stage of the operation on the twenty-one-year-old lad was performed June 14, 1913, under chloroform anesthesia. As the epileptic attacks began with twitching of the head to the left and contractions in the left hand, not only the original point of injury on the forehead, but also the right central region, had to be exposed. This exposure was carried out in the regular manner by means of an osteoplastic flap, the base of which was directed

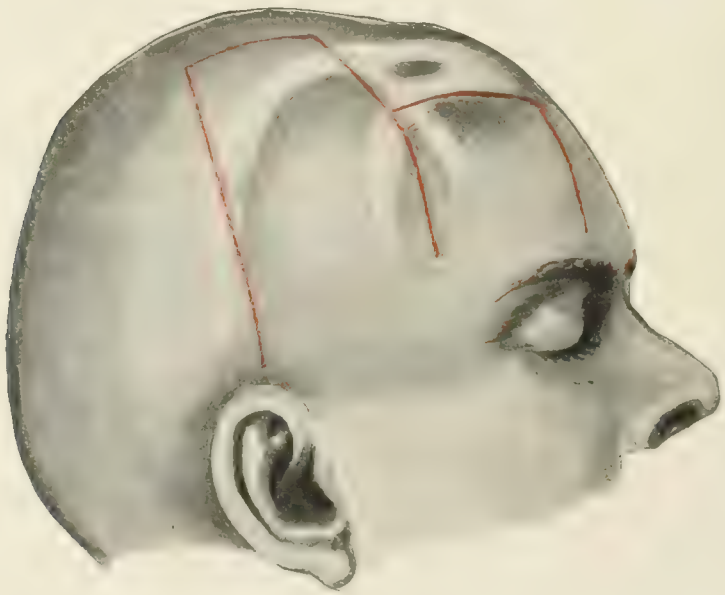


FIG. 645
Incision for plastic on skull and dura.

downward. For the exposure of the injured frontal portion, a smaller additional flap was made with the base downward, over the eyebrow. In this region a round plate of bone, of a diameter of 3 cm., had been transplanted over the defect by the Müller-König method nine and one-half years before by other surgeons; its rough, irregular inner surface lay directly upon the brain (Fig. 646, Plate 109). Dura, arachnoid, and pia were wanting; the surface of the brain showed an irregular depression and lay considerably below the surrounding level.

The dura of the central region presented an increased tension and appeared in the anterior half of the osteoplastic opening to be

Restoration of the dura mater by fascia lata, after Kirschner.

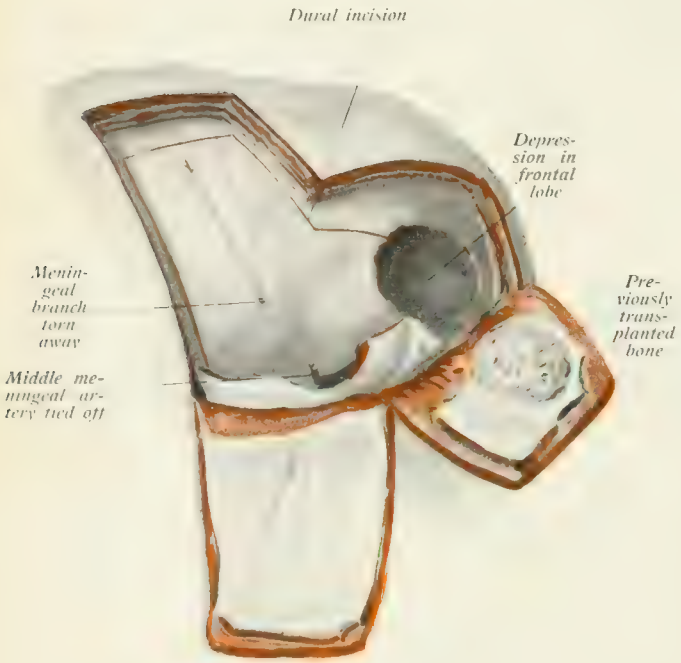


Fig. 646. Exposure of the dura mater and of the injured area in the frontal brain.

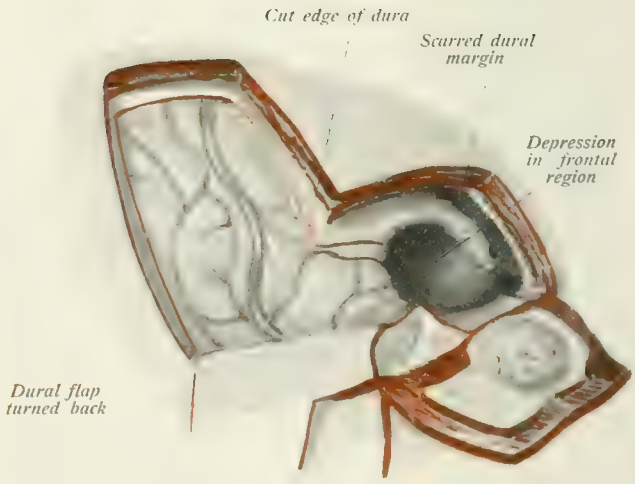


Fig. 647. Exposure of the brain over the operative field.

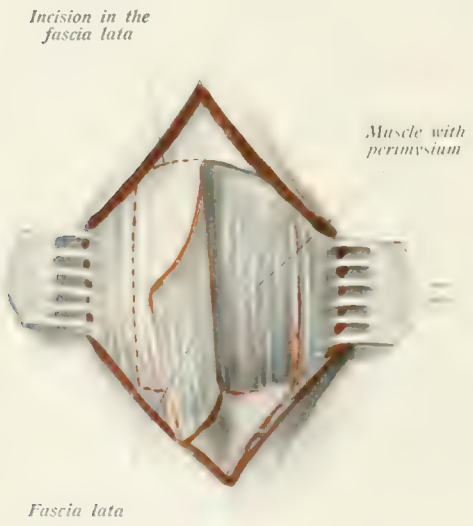


Fig. 648. Excision of the flap in the fascia lata.

Fig. 649. Free transplantation of fascia.

lifted up from the brain by fluid. It was, accordingly, a case of cystic-like collection of cerebro-spinal fluid (chronic circumscribed serous meningitis). In freeing up the anterior osteoplastic flap, the dura at the point of transition to scar tissue on the brain suffered a small tear, and several teaspoonfuls of clear fluid ran out, whereupon the dura collapsed. The middle meningeal artery ran in the lower third of the central region in a bony canal, and in turning back the bony plate it was torn, which induced rather severe hemorrhage. Moreover, a rather severe hemorrhage arose from the diploëtic veins, so that the patient collapsed at the end of the operation, and the completion had to be postponed to a second stage. After passing a tie around the meningeal artery on a needle and hammering the diploëtic veins, the first stage of the operation ended, and both flaps were sutured carefully into their original places by means of skin sutures.

The wound healed normally without marked variations in pulse or hemorrhage. On the fourth day following operation the sutures were removed. During the first three days severe vomiting occurred every morning on waking up, and recurred later. The patient received bromides for several days before and following the operation, and this medication was continued for ten days following the second stage.

This took place June 19th. The osteoplastic flaps were freed up by blunt dissection in the regular manner, and the blood clot lying upon the dura was removed. Then the dura over the central region was turned back in the form of a flap with the base below, but the anterior incision was continued forward into the defect in the frontal region (Figs. 646, 647, Plate 109). Three spurting branches of the meningeal artery had to be tied off at the margin of the incision. The arachnoid showed moderate edema, which disappeared after several superficial incisions.

About the old defect the dura was adherent to the inner plate, and particularly on the medial and upper sides. The adhesions were loosened by blunt dissection, allowing the brain to sink back, with the result that the deep hollow in the frontal region flattened out considerably. The slight bleeding at the point of separation of the adhesions was controlled by light compression with sponges. The dural flap of the central region was turned back over its old place, and on the anterior side it was fastened with one catgut suture.

In order to close the defect of the dura over the frontal region by plastic methods, a round flap of fascia nearly 4 cm. in diameter was required; accordingly, to allow for contraction, it had to be taken considerably larger. On the outer anterior side of the thigh, in the region below and in front of the great trochanter, a longitudinal incision was made through the skin, and a fascial flap 4 cm. across and 5 cm. long was dissected up with the least possible mechanical injury and was freed from all fat with the knife (Fig. 648, Plate 109). This we placed over the depression in the brain and over the surrounding dura, with the side which originally lay next to muscle lying in opposition to brain (Fig. 649, Plate 109), and it was lightly pressed into place with a sponge so that it stuck. It lay accordingly between the inner surface of the bone and the normal dura surrounding the defect, with its central portion lying practically over the depression. The fascia contracted very little, so that a superfluous strip could be trimmed off with scissors. Over the fascial flap the anterior osteoplastic flap was fitted and held by careful suture. The dural flap which had been turned back over the central region was purposely not sewed in place in order to leave above and on either side a narrow opening (2 mm. wide) for relief of the edema. Over this the osteoplastic flap was likewise sutured.

After this technique a muscle hernia at the point from which the flap is taken is not to be feared; however, the defect in the fascia lata in this case was closed in a line by nine catgut sutures, and over this the skin was sutured.

The wound healed by first intention, without marked variations of pulse or temperature. The highest temperature on the third and fourth evenings following the operation was 100.2, and the highest pulse rate was 80. No cerebro-spinal fluid came away, so that the dressing was changed for the first time, and the stitches were removed, on the fifth day. The patient following the second stage had neither vomiting nor headache, and slept well. On the fourteenth day he got out of bed, and a few days later, feeling entirely well, journeyed back to his fatherland. Up to October, 1913, no convulsive attack had occurred. From our point of view a final judgment on this case cannot be made within five years at the earliest. But the patient has felt very well, both mentally and physically.

In other cases we are forced to slip a flap of fascia *under* the surrounding dura. We had to perform an operation of this sort on a fifteen-year-old boy, who when he was five months old had his head crushed in a mangle. Beginning the sixth year he had slight convulsions every three or four months, but from the thirteenth year on they were more frequent and more severe. The physician who sent him in for operation had observed that the attacks always began in the right forearm.

In the middle of the central region there was found a furrow in the skull which would just about take half of the forefinger. Exposure of the entire central region by a flap 10 cm. long by 8 cm. wide showed very severe changes. Bone was wanting over an area the size of a half dollar just below the furrow, and almost as far as the upper margin of the osteoplastic opening the dura was entirely wanting for a width of 4 cm. The surface of the brain and particularly the arachnoid had become adherent at this point to the structures which covered it, that is to say the bone, and where the bone was wanting, with periosteum. So tightly was it adherent that considerable force had to be used in separating it.

Below the defect the dura was 4 mm. thick, and within its substance upon its inner surface there were a number of flat plates of bone up to 15 by 25 mm. in size (compare p. 517, Plate 86). Moreover, there were several adhesions, some flat, others threadlike, between the inner surface of the dura and the arachnoid. After these had all been carefully freed up, there were found also in the arachnoid several small plates of bone which possessed a rough surface, and at times showed spicules. The largest of this sort of bony growth measured 6 by 5 mm. over its surface and was 3 cm. thick. It is not remarkable that such severe alterations immediately upon the surface of the central region should give rise to epilepsy.

All of these bony formations were removed until finally the exposed surface of the brain, except for the place where the adhesions had occurred, appeared smooth and covered with normal appearing arachnoid. The dura, on account of the severe changes which it showed, could not be preserved without running the risk that new manifestations of irritation would make their appearance. It was removed over the entire extent which showed any changes, which resulted in a defect 8 cm. long by 6 cm. wide.

This defect was replaced by fascia lata taken from just below the insertion of the tensor fasciæ femoris muscle. Through a longi-

tudinal incision 16 cm. long a flap of fascia of considerably greater size was dissected out and immediately placed upon the surface of the brain, that is to say between the pia-arachnoid and the inner surface of the dura, so that the margin of the transplanted flap was covered all about by the edges of the dura. Over this the osteoplastic flap was fastened by carefully suturing the skin.

The large defect in the fascia lata could be so far closed by interrupted catgut sutures that only a narrow slit 7 cm. long and in the middle 1½ cm. wide remained uncovered. Over this the skin was sutured.

Healing followed without incident, and the boy returned to his home four weeks after the operation. According to the news which we have had of him through correspondence, he has remained well.

EMPLOYMENT OF THE DURA ITSELF FOR PLASTIC PURPOSES

In addition to the fascia lata, we can use the dura also, if it possesses the necessary strength, for the formation of new flaps. If it is incised through its upper layer with a knife at some distance from the defect, and by careful dissecting, it is separated into two layers. The uppermost layer is seized with fine forceps and dissected up to a point near the margins of the defect. The flap is taken ¾ cm. wider and ½ cm. longer than the defect.

The upper layer of the dura forms the flap, the base of which lies at the margin of the defect. Thus by turning it over through an arc of 180 degrees it may be laid upon the surface of the brain so that its former external surface becomes internal, and it is made fast by a few catgut sutures.

In the region of the Pacchionian granulations the formation of a flap from the dura is difficult and should not be attempted. Infiltration of the dura with salt solution makes it much easier to divide it into layers. The method has been worked out on cadavers and in animal surgery, and has also been employed in man with success.

This technique originated with August Brüning.* Naturally, flaps may be split off from the dura on more than one side of the defect.

ENCEPHALOCELE

If a congenital defect occurs in the skull and membranes, the cranial contents protrude beneath the intact skin so as to form a

* Deutsche Zeitschrift für Chirurgie, Vol. CXIII, p. 412.

cerebral hernia, which retains its connection with the cranial cavity. Such congenital formations are called cephaloceles and are located in the middle line. They occur most frequently in the occipital fossa (superior occipital cephalocele above the external occipital protuberance, and inferior below), less frequently at the glabella and root of the nose (sincipital, naso-frontal, naso-occipital or naso-ethmoidal cephalocele according to the point at which it takes its exit from the cranium). The contents may consist chiefly of fluid and they communicate with one of the ventricles. In other cases, in addition to fluid, cerebral tissue with its pia and arachnoid occur in the sac.

As to diagnosis, the location is important; in addition, there is the possibility of reducing the entire contents or a portion thereof into the cranial cavity, which at times arouses acute manifestations of increased cerebral pressure. The bony margins may be palpated, or may be recognized in the X-ray plate.

If there occurs at the same time, in conjunction with the congenital tumor, deformity of the skull and of the brain, or if there exists anywhere else in the body a severe deformity which may be fatal, operation should be rejected. But if the general condition allows it, one should not limit himself to pressure dressings and puncture, or at most should employ those only until the child has become older and stronger, and at that time should extirpate the tumor and follow this by a plastic closure of the defect, for the prognosis of the deformity is very unfavorable. Generally speaking, it is a good rule not to operate on those children who have at the same time a congenital hydrocephalus, or in whom hydrocephalus rapidly develops. We have once, however, in such a case been forced to operation by the spontaneous rupture of a cystic sac in order to forestall what seemed to be certain death, and obtained a surprisingly good result. A description of this case will at the same time make clear the technique of the operation.

OCCIPITAL ENCEPHALOCELE WITH HYDROCEPHALUS

An otherwise normally developed, but weak, baby girl was delivered with difficulty at the end of eight months on May 24, 1911, weighing 4½ pounds and having an occipital encephalocele. The circumference of the head at that time, according to the statement of the physician, was not far from normal. But it soon began to increase, as well as the circumference of the occipital tumor; on June 30th its semicircular periphery from above downward measured 45,

and from right to left likewise 45 mm.; on July 20th, 56 by 58 mm.; on September 10th, 80 by 90 mm., and on September 21st, 100 by 94 mm. The horizontal circumference of the head increased during the same period from 49 to 52½ cm. The sac in the occipital region (Fig. 650, Plate 110) was under very great tension, and was covered by very thin hairless skin, which was translucent.

As radical operation could not be considered in the weak four-months-old child, we limited our treatment to puncture, and on September 26th punctured the right lateral ventricle from above, and also the cystic sac at its base, carrying the aspirating needle through a very long canal in the surrounding soft parts, in order to prevent the formation of a fistula. But in spite of the complete emptying of the sac and a marked diminution of the hydrocephalus, both rapidly filled up again, and accordingly the punctures were continued every fourth week up to February 22, 1912. The child showed no marked disturbance from this treatment, and following this date was not brought back again for treatment for three months.

At the next examination, on May 29th, the circumference of the head was 55½ cm., and the circumference of the encephalocele had increased to 165 mm., so that both punctures had to be repeated after this interval of three months. On June 3d the dressing, which up to that time had been dry, was found to be completely saturated. On changing the dressing there was found in the middle of the sac, the punctures always having been carried out at its base, a fistula the size of a knitting needle, through which clear fluid was issuing. Surrounding this fistula the skin of the sac for a fingers' breadth was covered with pus and showed superficial necrosis.

In order to prevent infection and the imminent danger to life which it would entail, excision of the sac could not be postponed any longer. It was undertaken under light ether anesthesia, June 3, 1912. The sac was flaccid, but still about the size of a child's fist. The fistulous track, secreting pus, was closed tightly by means of a clamp, in order to prevent cerebro-spinal fluid from coming away, and to allow of disinfection with benzine and iodine. The entire sac was then excised with an oval incision directed sagittally (Fig. 650, Plate 110), so that a strip of skin about 3 cm. wide was left on either side.

After the clear fluid contents had been allowed to flow off, the inner surface of the sac was seen to have a smooth covering, the

Extirpation of an inferior occipital encephalocele.

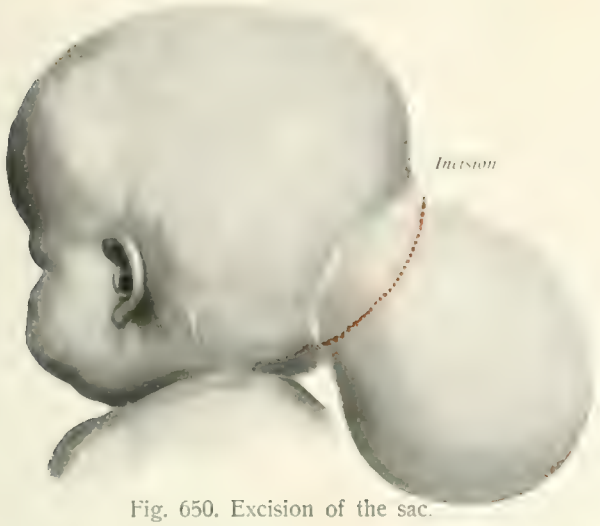


Fig. 650. Excision of the sac.

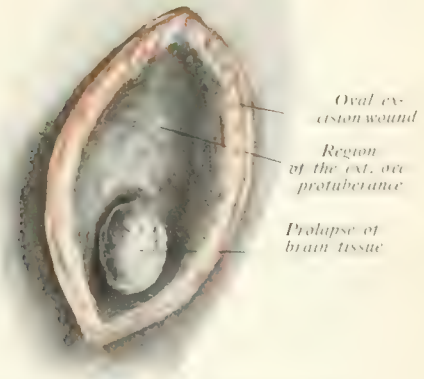


Fig. 651. Defect in the occipital fossa exposed.

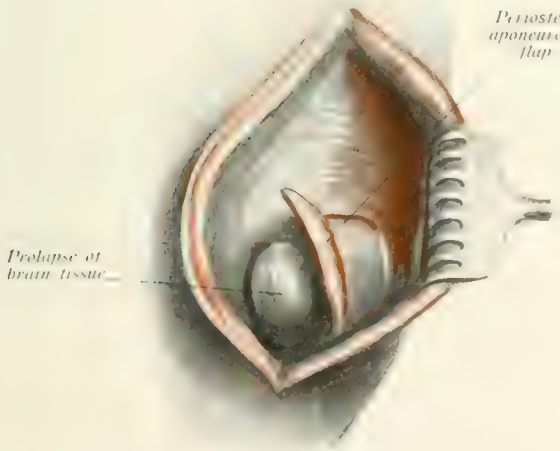


Fig. 652. The defect in the skull is covered by a flap of periosteum and galea.

Fig. 653. The flap is sewed over the opening.

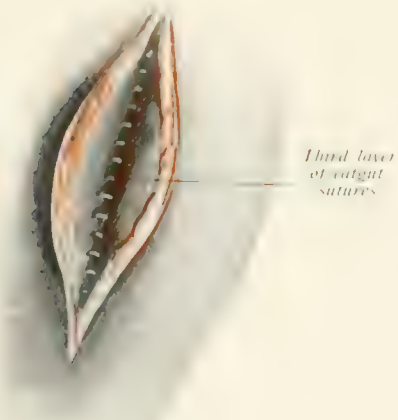


Fig. 654. The tissues are sewed up in layers.

Fig. 655. Condition 6 weeks after operation.

underlying layers of which, however, showed a brawny infiltration. The dura, arachnoid, and pia could not be differentiated as separate layers. In the apex of the funnel-shaped opening there projected a brownish-red spongy mass of tissue about the size of a finger-tip, which as the child cried increased to the size of a plum (Fig. 651, Plate 110); this was evidently brain tissue. The opening in the skull through which this mass projected lay in the middle line, not far below the external occipital protuberance, and it could just about admit the finger. Its edges were entirely smooth.

In order to close this opening, the sac was first dissected away and at its base a flap of periosteum and aponeurosis of a considerably larger size was cut over the right occipital region, in such a way that its pedicle lay to the right of the opening (Fig. 651, Plate 110). The thick flap was then turned to the left over this opening and was sewed tightly about it with interrupted catgut sutures in such a way that the hole was closed, and even when the child cried the brain substance no longer protruded (Fig. 653, Plate 110).

In order to give better support to this periosteal closure, the skin flaps which remained on either side were employed. First the smooth edematous cyst wall was freed up from their inner surface, which could be done by putting them under strong tension and by wiping the tissue away with a sponge, using the knife when necessary. Then the basal portion of the two skin flaps were joined with interrupted catgut sutures, and over this a second and then a third layer of sutures were placed (Fig. 654, Plate 110), so that a strip of skin 1½ cm. high lay over the periosteal flap. Finally, after cutting away the superfluous skin, the external wound was closed with silk. The operation lasted forty minutes, and the child lost practically no blood and was in good physical condition.

The temperature that evening rose to 100.6 and the pulse to 116, on the next evening to 102.2 and 140, on the third evening it fell to 98.4 and 116, but on the fourth evening it rose once more to 100.6 and 124. From that time on, pulse and temperature were normal. No cerebro-spinal fluid came away. At the first change of dressing, on the twelfth day, the wound was found to be healed, and the stitches were accordingly removed. The fistula made by puncture, which was likewise present over the right lateral ventricle at the time of operation, and gave exit to a few drops of clear fluid, was closed and dry.

After the operation the child no longer vomited, although after

each puncture it had vomited four or five times in succession, and occasionally at meal time. If the cerebral pressure rose, vomiting had also appeared in the intervals between punctures. The dressing was omitted on June 29th, as the scar was solid. From this time on the activity and the interest of the child increased markedly, it was happier and it played, and physically it was in good condition. After the eighth day following the operation it slept through the entire night. On July 2d the circumference over the frontal protuberance and the external occipital protuberance was 55 cm., from the upper margin of one ear to the other measured, across the forehead, 33 cm. The scar was solid and did not bulge (Fig. 655, Plate 110). The opening in the bone could only be indistinctly felt at the lower angle of the scar. On crying, a small flat area, the size of a cherry-stone, bulged. The anterior fontanelle measured 4 cm. across and 5 cm. in length. The posterior fontanelle was practically closed. The forehead was high, but it projected forward only slightly.

On July 17th we found that the child was already speaking several words and the intelligence had improved, if it were at all behind that of other children. She recognized her surroundings and could carry her heavy head without support, and could sit upright for two or three hours at a time, but she could not yet walk, nor did she attempt it. In December, 1912, at the age of a year and a half, the patient could stand, but not walk. The slightly protruding scar felt solid. The anterior fontanelle had become considerably smaller; it did not bulge, but it seemed rather to be below the level of the surrounding skull. The face was no longer too small in comparison with the large cranium, the circumference of the head was the same as that at the time of operation. The child was animated and jolly, and appeared to be but little behind a normally developed child of the same age. Her appetite was good, and she slept well; iodine had not been given internally since the operation.

In January, 1913, the child began to walk, and from that time on, to the great joy of its parents, developed normally. At the last examination, a year and a quarter after the operation, we found the scar solid, except in the lower angle where there was a soft place the size of a pea, which did not bulge on crying. This place was present ever since the wound had healed, and it had not increased in size since July, 1912. The largest circumference of the head was 56 cm. The posterior fontanelle was completely closed,

as well as the suture lines. The anterior fontanelle had closed down to an area smaller than a dime, but it did not pulsate even on crying, and it did not bulge in the least. The child had improved remarkably, she repeated anything that was said to her; in her mental development she appeared to be perhaps about six months behind the normal, but she seemed particularly bright. She was strong and well developed physically. She had begun to walk about six months later than her two brothers. No abnormality in the central nervous system could be demonstrated. The circumference of the head had decreased somewhat.

This unusually favorable result must be considered as evidence that the hydrocephalus in this case was kept up by the encephalocele, and after this was removed it disappeared.

PERICRANIAL SINUS

By pericranial sinus (Strohmeyer), a quite unusual disease, we understand, according to the words of E. von Bergmann, "a cyst situated beneath the periosteum of the skull containing circulating blood, which communicates by means of a good-sized emissary vein with the longitudinal sinus." The majority of cases give a history of a precedent trauma.

Our case was a forty-seven-year-old mason, who when an apprentice, at the age of seventeen, fell from a ladder and struck on his head. At the age of twenty-two years he noted on stooping or coughing a protuberance about the size of a bean on the left side of the forehead, which gradually grew in size through the following years. At first the swelling caused no symptoms; but in the last few years, every time he sniffed he felt as if his head was going to break open. He complained, however, of headache and vertigo if he bent over, and at the same time the tumor increased in size; the symptoms were not present if he stood upright.

Standing erect, the patient showed two finger breadths above the glabella on the left side of the forehead, 1½ cm. from the sagittal line, a shallow fossa (Fig. 656), over which the skin was normally movable. On palpation, one could feel almost exactly in the middle line a fissure in the bone 1½ cm. long and a few millimeters wide, which began in the middle line .5 cm. above the glabella and ran obliquely downward and to the left, ending 2½ cm. from the left upper margin of the orbit.

On stooping, during the course of a few seconds swelling ap-

peared, which, at first pulsating and later without pulsations, gradually grew larger until it reached the size of a plum (45 mm. high, 5 mm. across), projecting finally 1½ cm. above the surrounding level of the skin, and which clearly showed fluctuation. Beneath the skin, which remained normally movable, there ran over the tumor two dilated veins (Fig. 657). No vascular murmur could be heard; the tumor could be emptied by means of pressure with the finger. When the patient stood upright again, the tumor disappeared with considerable rapidity and the veins emptied themselves, first in the upper

FIG. 656
Pericranial sinus, empty.

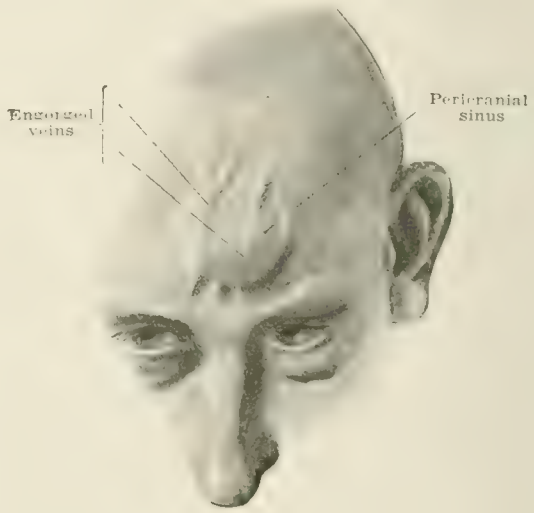


FIG. 657
Pericranial sinus, filled with blood.

two-thirds, while the swelling persisted a little longer in the lower third.

There could be no question but that the cyst filled itself and emptied itself of fluid. The same picture that we have just described could be induced by compression on the two jugular veins, and it occurred also if the patient strained or coughed. The X-ray showed a small, barely visible fissure in the skull; the frontal sinus extended for a considerable distance upward, but showed no abnormality.

Operation was indicated because the patient's ability to work was greatly diminished by the continuous sense of pressure in the head. Moreover, this abnormal sinus, lying just beneath the skin, involved a certain danger of hemorrhage, because even a wound of no great

Extirpation of a pericranial sinus.

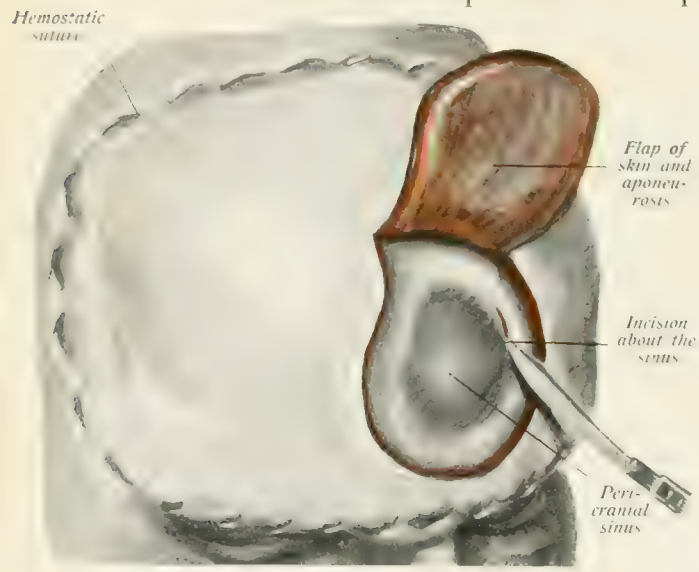


Fig. 658. The sinus is exposed, and a circular incision is made about it.

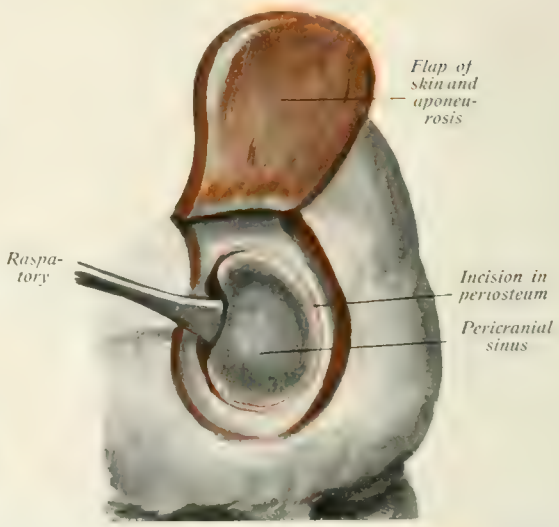


Fig. 659. The sac of the sinus together with the periosteum is freed up with a dissector.

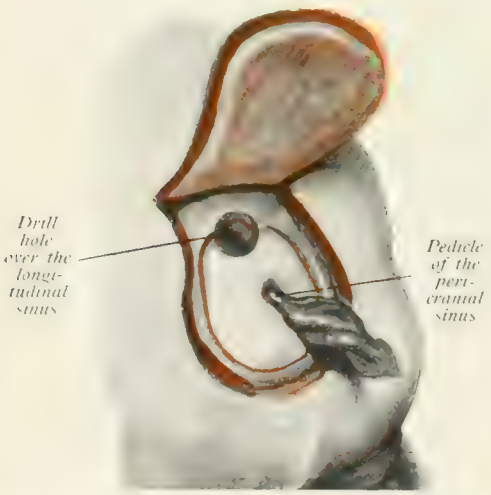


Fig. 660. The bone is bared by the removal of the periosteum.

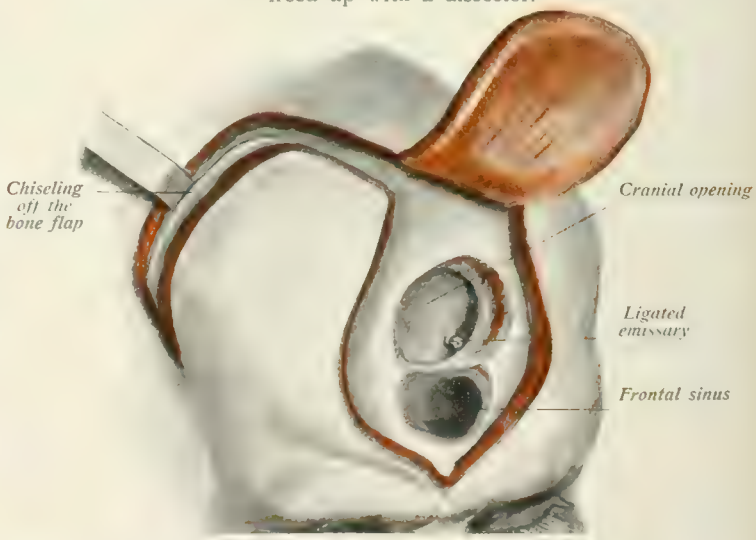


Fig. 661. Bony defect; formation of osteoplastic flap.

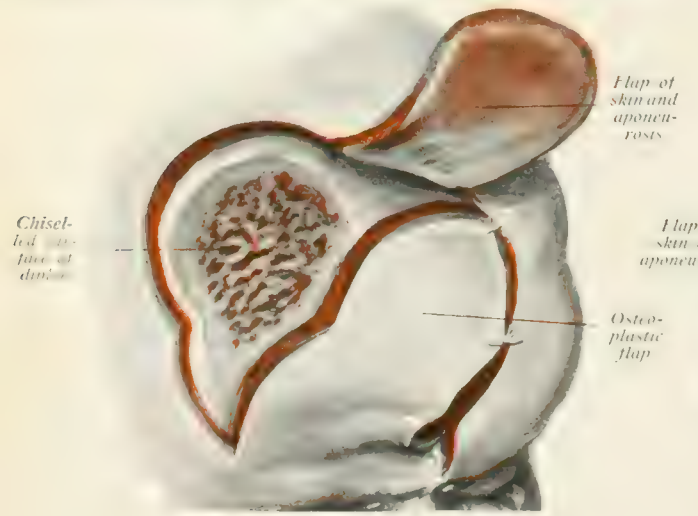


Fig. 662. Osteoplastic closure completed.

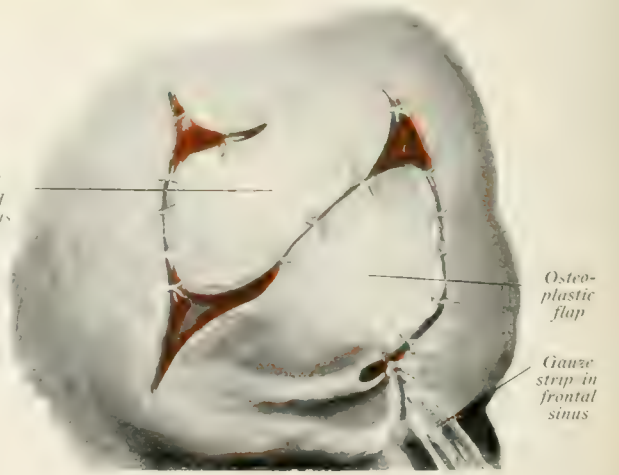


Fig. 663. Condition after sewing in the two flaps.

depth might readily cause profuse hemorrhage from the sinus. In a similar manner, for instance, an old person with varicose veins may bleed to death because the weakness resulting from the hemorrhage prevents her from applying any compression dressing.

The operative plan was as follows: The emissary vein which connected the intracranial sinus (in this case evidently the longitudinal) with the pericranial sinus, was to be tied off close to the intracranial sinus. To accomplish this it was absolutely necessary to increase the small opening in the bone which was already present. The opening which was thus formed was to be closed by bone, using the König-Müller technique. The bone flap to be employed, on account of the great extent which the frontal sinus showed in the X-ray plate, would probably open up this cavity.

It seemed to the best advantage to place the base of the skin and bone flap downward, which would bring the upper transverse scar in the hairy scalp, where it would not be visible. Moreover, it seemed advisable to lay out the osteoplastic flap in the right frontal region, as the pericranial sinus projected beyond the middle line more on the left than on the right.

The operation was carried out in the following manner. As the tumor disappeared entirely when the patient was lying on his back, the jugular veins were compressed, and when the tumor filled itself, its circumference (tincture of iodine having been previously applied to the skin) was marked with a knife scratch; the area was larger than a half dollar. The hemostatic suture was then applied, a flap of skin was made corresponding to the knife scratch, but with its pedicle above, and after the dilated skin veins were double-tied and divided, the skin and aponeurosis were dissected up, until the sinus was completely exposed.

The sinus could be seen as a flat, dark-bluish protuberance, which bulged slightly, and every time the breathing was obstructed it became larger in size (Fig. 658, Plate 111). The width of the skin flap was 4 cm., and the length from above downward slightly greater. As the sinus lay beneath the periosteum, this was cut in a circle about it down to bone, and the sinus, together with the periosteum covering it, was shoved backward from periphery to the center with a wide bone scraper (Fig. 659, Plate 111), until in the middle we came upon the pedicle, which was about as large as a good-sized knitting needle and about ½ cm. long (Fig. 660, Plate 111).

In order to follow this pedicle as far as the longitudinal sinus, a certain amount of bone had to be removed in this vicinity; for if it were tied off outside the cranial cavity, a recurrence might readily come about. Accordingly a drill-hole was placed above in the middle line exactly over the longitudinal sinus, and with rongeurs an opening about the size of a quarter dollar was made around the emissary. During this process the frontal sinus was opened below. As the patient suffered from chronic rhinitis, the frontal sinus was packed downward with a strip of iodoform gauze. In order to be able to remove this packing more easily when the dressing was changed, independent of the osteoplastic flap to be used for plastic purposes, the anterior wall of the frontal sinus was broken away still further below over an area the size of a nickel, the skin was divided vertically downward over it, and at the lower angle of this wound the gauze strip was brought out (Fig. 663, Plate 111).

In all the manipulation of the bone, nowhere could evidence of an earlier injury be demonstrated. The pedicle of the pericranial sinus which opened into the longitudinal sinus was tied off close to this vessel by means of fine catgut, and cut away distally to the tie. The bony opening in the cranium measured from right to left 23, and from above downward 20 mm. The lateral margins of the longitudinal sinus were not exposed, but remained hidden beneath the bone.

Now, to serve as a cover for the defect, an osteoplastic flap with its base below was formed on the right side of the forehead; its width was 4 cm. and its height 5 cm. (Fig. 661, Plate 111). In order to include in this flap, in addition to skin and periosteum, the outer table of the bone down to diploë, the external plate was chiseled through in a line around the margin of the periosteal incision, and then with the bayonet chisel of Küster, designed for this purpose, the external plate was chiseled off in its entirety. The bony plate measured 38 mm. across and 40 mm. long. The pedicle of this flap was then mobilized by running an incision obliquely downward from the outer lower angle of the wound down to bone, and the periosteum over the entire width of the flap was scraped away.

Thereupon the osteoplastic flap could be turned inward at practically a right angle and fitted in over the defect; it was carefully sewed in place, while the original skin flap, after loosening up the periosteum extensively, was displaced over the chiseled surface and

Re-implantation of skin flaps, for cosmetic reasons.

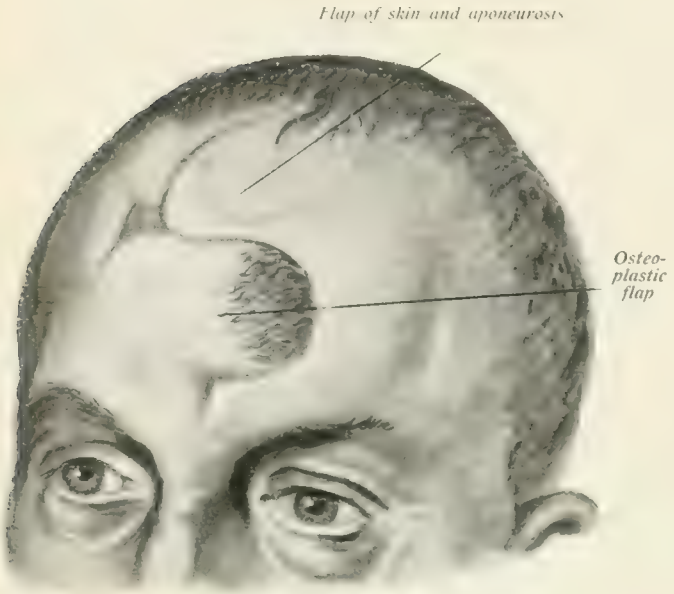


Fig. 664. Condition 8 weeks after the osteoplastic operation.

Fig. 665. Freeing up the flap in subcutaneous tissue.

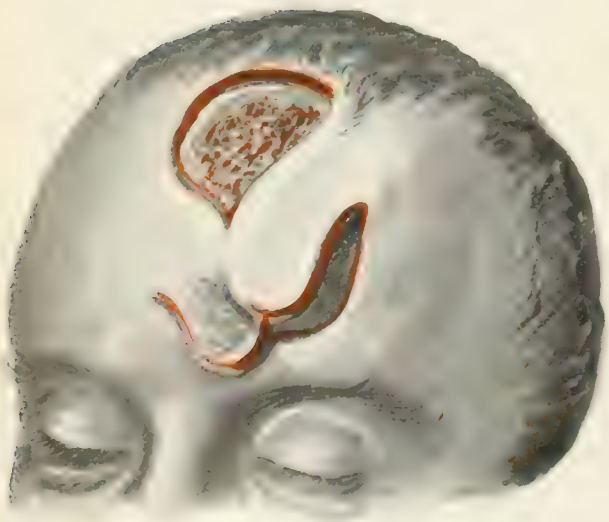


Fig. 666. The two skin flaps, after being dissected up, are restored to their original sites.

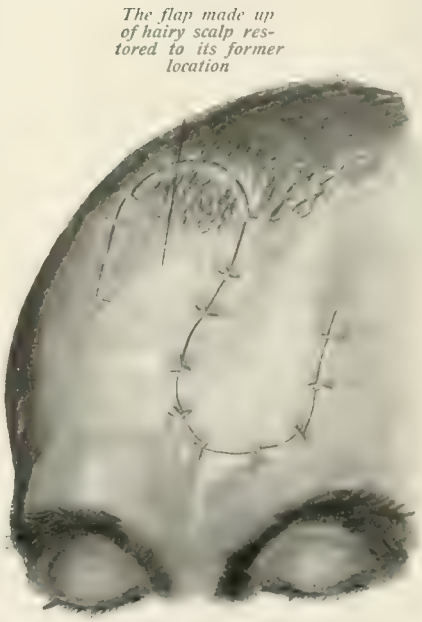


Fig. 667. Result.

sewed in place (Fig. 663, Plate 111). In this manner the entire wound could be closed except for small defects at the angles. Naturally, care was taken that as the result of the suture, no tension of such a degree as might interfere with nutrition occurred in the flap.

The post-operative course was normal, without rise of temperature; no portions of bone came away. On the sixth day the gauze strip was removed from the frontal sinus, which had been opened, and at the same time most of the sutures were taken out. The last sutures were removed on the tenth day. The small defects at the corners granulated in well, and under occasional applications of silver nitrate had scarred over six weeks after the operation.

As the osteoplastic flap extended into the hairy scalp, there resulted a growth of hair in the middle of the patient's forehead (Fig. 664, Plate 112). This ludicrous deformity could be very simply corrected by once more freeing up the two skin flaps and replacing them in their original positions (Figs. 665 and 666, Plate 112). Naturally on this occasion only skin, together with subcutaneous fat, were included in the flap. The periosteum as well as the transplanted bone were not disturbed. This operation was undertaken eight weeks after the first operation and gave the desired result (Fig. 667, Plate 112), which was also entirely satisfactory to the patient. He has remained free of symptoms during more than four weeks which have passed since the last plastic operation was performed.

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